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Research

A large multi-centre study utilising electronic health records to identify antimicrobial prescription risk factors for dogs and cats

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Running title: Risk factors for antimicrobial prescription in dogs and cats

Article summary: This large multi-centre companion animal electronic health record-based multivariable analysis study demonstrated the utility of such data repositories and methodologies to understand clinical presentation prescription variation, the role of preventive healthcare in antimicrobial prescription decision making, and how such factors might be used to encourage responsible antimicrobial use in dogs and cats.

Keywords: Epidemiology; pets; dogs; cats; veterinary; informatics; anti-bacterial agents

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Abstract

Antimicrobial stewardship is a cornerstone of efforts to curtail antimicrobial resistance dissemination. However, little is known about factors potentially influencing likelihood of companion animal antimicrobial prescription. Here, we analysed unwell canine (*n*=155,732 unique dogs, 281,543 consultations) and feline (*n*=69,236 unique cats, 111,139 consultations) electronic health records (EHRs) voluntarily contributed by 173 UK veterinary practices, using multivariable mixed effects logistic regression. Preventive health-focused owner care decisions including vaccination (dogs: odds ratio, OR 0.93, 95% confidence interval, CI, 0.90-0.95; cats: OR 0.92, CI 0.89-0.95), insurance (dogs: OR 0.87, CI 0.84-0.90; cats: OR 0.82, CI 0.79-0.86) or neutering in dogs (OR 0.90, CI 0.88-0.92) were associated with decreased systemic antimicrobial prescription odds, as were dogs presenting to Royal College of Veterinary Surgeons accredited practices (OR 0.79, CI 0.68-0.92). This large multi-centre companion animal EHR study successfully demonstrated the potential of preventive healthcare and owner engagement to encourage responsible antimicrobial use.

Biographical sketch

David Singleton is a veterinary surgeon with an interest in observational and interventional epidemiology, health informatics and antimicrobial resistance within a one health framework. Much of his work has utilised electronic health record data collated by the Small Animal Veterinary Surveillance Network (SAVSNET), based at the University of Liverpool, and he is currently employed within this group as a post-doctoral research associate.

Introduction

Antimicrobial use is a key driver in the promotion and transmission of antimicrobial resistance (AMR) in humans, livestock (e.g. chickens, pigs etc.), and companion animals (e.g. dogs and cats) (*1-5*). Of these groups, the important role of companion animals for development (*1,2*), carriage (*6*) and transmission of AMR bacteria both within animal populations and to/from humans, due at least in part to the close proximity in which companion animals reside with humans (*5,7,8*), is now being increasingly realised. Indeed, companion animals are now included in recent global action plans aimed at tackling the important global AMR health threat (*9*).

Both electronic health records (EHRs) and qualitative research techniques have been used extensively in human medicine to identify many practitioner and patient-led factors associated with antimicrobial prescription likelihood (*10-13*). In veterinary medicine, studies investigating antimicrobial prescribing practices and related risk factors are more limited (*14*). To date, companion animal research has largely focused on postal surveys (*15,16*) and in-person interviews (*17*) to explore perceptions held by veterinary practitioners. However, recent veterinary health informatics advances have provided opportunities to utilise veterinary EHRs at scale to survey antimicrobial prescription (*18,19*).

Thus far, key insights into antimicrobial prescription frequency and variety have been demonstrated (*20-23*), including an apparent increase in feline cefovecin use (*21,22*), a third generation cephalosporin considered ‘highest priority critically important’ (HPCIA) by the World Health Organization (24). Considerable inter-practice (*20,22*) regional (*21*) and clinical presentation (*22,25,26*) variability in antimicrobial prescription frequency and choice has also been identified. Though previous studies have indicated divergence of veterinary

opinion over when antimicrobial therapy is justified, and which antimicrobial classes would then be most appropriate (*15-17*), why such observed variation exists is currently unknown.

There remains a need to identify factors potentially influencing antimicrobial prescribing in the clinical environment. This study utilised the EHRs of a large, diverse veterinary-visiting population of dogs and cats collected from a network of volunteer first-opinion veterinary practices across Great Britain. We explored associations between antimicrobial prescription (including antimicrobials authorised for systemic administration; antimicrobials authorised for topical administration, and HPCIAs) and a range of veterinary practice, practitioner, owner, and animal-related factors (including socioeconomic factors and preventive healthcare interventions) in animals recorded as primarily presenting for investigation of disease.

Materials and methods

Data collection

This cross-sectional study used EHRs from 178 volunteer veterinary practices (386 unique sites) taking part in the Small Animal Veterinary Surveillance Network (SAVSNET, University of Liverpool ethical approval reference: RETH000964), utilising the Robovet practice management system (Vet Solutions Ltd.). EHRs were retrieved from booked consultations (*19*) between 1st April 2014 and 31st March 2016. Each consultation record included species, breed, sex, neuter status, insurance status, microchip status, vaccination history, date of birth, owner's postcode and any products dispensed at time of consultation. Every consultation record was further classified by the attending veterinary professional into one of ten main presenting complaints (MPCs) (grouped into 'healthy'; 'unhealthy', or 'post-operative' categories), indicating the main reason the animal was presented to the veterinary practice, as previously described (*22*).

Data management

General data management

There were 762,648 canine and 300,606 feline consultations initially available. Animals with likely incorrectly recorded dates of birth (dogs and cats exceeding 24.5 and 26.0 years of age at consultation, respectively) were excluded (*n* canine = 1,577; *n* feline = 2,467), as were animals lacking a valid owner's postcode (*n* canine = 23,705; *n* feline = 9,901). Only consultations where animals were recorded as unhealthy (hence, 'sick animal consultations') by MPC were used in this study (282,263 out of 737,366 remaining canine consultations and 111,367 out of 288,238 remaining feline consultations). Veterinary practices (*n*=5) providing insufficient EHRs for adequate statistical analyses (less than 50 consultations) were also removed.

Antimicrobial prescription was identified via the text-based product description and classified into systemic (oral or injectable) or topical (topical, aural, ocular) administration routes, using a semi-automated rule-based text-mining method as previously described (*22*). All fluoroquinolones, macrolides and third generation cephalosporins were considered HPCIAs (*24*). Antimicrobials authorised for dog and/or cat use in the UK are summarised in Supplementary material, Table S1.

Animal factors

Animals were considered vaccinated if the most recently recorded vaccination date (disregarding vaccine composition) was less than or equal to 3.5 years (broadly reflective of current vaccine interval guidelines) before the relevant consultation date (*27*). Breeds were summarised to standardised breed terms (*28*) before categorisation into either genotypically

similar breed groups (*29*), crossbreeds, breeds not yet genetically classified ('unclassified'), or breed not recorded/recognisable ('unknown').

Owner factors

Using pet owner's home postcode, a measure of predicted deprivation was assigned to each owner using the most recent English 2015, Scottish 2012 and Welsh 2014 Indices of Multiple Deprivation (IMD). As IMD measures between countries are not directly comparable, country was included in statistical models as a three-level factor and each country's complete set of IMD ranks were rescaled to the range 0 to 1, with 1 corresponding to the least deprived area.

We determined country of residence and urban/rural status via reference to the National Statistics Postcode Look-up. The recorded centroid associated with each postcode was utilised to place each animal owner within a 1 km^2 gridded cell, and each EHR was hence associated with an estimate of the number of dogs or cats within each 1 km^2 gridded cell as defined by Aegerter et al. (2017). Finally, postcode district was used to provide an estimate of the number of dogs or cats per household for each recorded postcode (*30*).

Veterinary practice and practitioner factors

The RCVS Practice Register was utilised (interrogated 18th October 2016) to summarise each veterinary practice by advertised treated species range into four categories: companion animal; mixed (companion animal, large animal and equine); companion and large animal; and companion animal and equine. Practices were considered accredited under the voluntary RCVS Practice Standards Scheme (PSS) if at least one site was recorded as accredited (Core Standards; General Practice, or Veterinary Hospital), and 'RCVS Veterinary Hospital' if

practices contained a Veterinary Hospital site. Practices listing 'referrals' as an interest were also recorded. Practices employing at least one veterinary surgeon holding 'RCVS Advanced Veterinary Practitioner (AVP)' status or separately 'RCVS specialist' status in areas of relevance to companion animals were also recorded.

Statistical analysis

The statistical programme 'R' was used for all analyses. Descriptive proportions and confidence intervals were adjusted for clustering within sites (bootstrap method, *n*=5,000 samples) (*31*). Univariable and multivariable mixed effects logistic regression models were fitted separately in dogs and cats using the R package 'lme4' (*32*). Likelihood ratio tests (LRT), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and evidence of inter-practice antimicrobial prescription frequency variation (*22*) indicated that observations were clustered within veterinary practice, site and animal; therefore, all three factors were included as random intercepts in all models. Separate analyses were undertaken to assess the association between explanatory variables and three binary outcomes of interest: antimicrobial prescription authorised for systemic administration ('systemic antimicrobial'); topical administration ('topical antimicrobial'); and systemically administered HPCIAs.

Initial univariable screening included fifteen categorical variables (sex, neutered status, microchip status, insurance status, vaccination status, genetic breed group, country of residence, owner urban/rural status, MPC, treated species ('practice type'), RCVS accreditation, RCVS Veterinary Hospital, referral interest, RCVS AVP, and RCVS specialist), and four continuous variables (age at consultation, rescaled IMD rank ('rIMD'), dog or cat population per km^2, and mean number of dogs or cats per household at district of residence). For continuous explanatory variables, up to cubic polynomial terms were included

if an LRT, AIC and BIC indicated significantly improved fit, compared to linear and lesser polynomial terms. Explanatory variables were retained for multivariable analysis if an LRT indicated $P \leq 0.20$ against a null model.

Multivariable models underwent manual step-wise backward elimination to minimise AIC and BIC. A two-way interaction between rIMD and the three-level factor country was included in the initial multivariable model (deleted if AIC and BIC decreased upon removal), with country alone as a false intercept. Confounding was accounted for via assessment of effect variation upon removal of variables. Two-way interaction terms between other explanatory variables were assessed via AIC, BIC and an LRT. The Variance Inflation Factor (VIF) was used to assess multicollinearity (*33*). For continuous variables, projected prescription probabilities and associated 95% confidence intervals were calculated from log odds using 'sjPlot' (*34*). Statistical significance was defined as $P<0.05$.

Results

Data from 281,543 sick dog (155,732 unique dogs) and 111,139 sick cat (69,236 unique cats) consultations from 173 veterinary practices (379 sites) were analysed. A descriptive population summary is included in Table 1, and a summary of genetic breed groups included in this study is included in Supplementary material, Table S2.

Dogs

Antimicrobial prescription

Systemic antimicrobials, topical antimicrobials, or systemic HPCIAs were prescribed in 25.7% (95% Confidence Interval, CI, 24.9-26.6), 14.2% (CI 13.9-14.6) and 1.4% (CI 1.2-1.6) of consultations. Fluoroquinolones were the most commonly prescribed systemic HPCIA

class (0.9% of sick consultations, CI 0.7-1.0), followed by 3rd generation cephalosporins (0.5%, CI 0.4-0.6) and macrolides (0.1%, CI 0.0-0.2). Antimicrobial prescription summarised by commonly consulted breed is summarised in Supplementary material, Table S3.

Systemic antimicrobial prescription

Descriptive analyses and univariable model results are summarised in Supplementary material, Table S4. Final multivariable model results are available in Table 2. Vaccinated or neutered dogs were less likely to receive a systemic antimicrobial prescription compared to unvaccinated or un-neutered dogs. Insured dogs were less likely than uninsured dogs to be prescribed a systemic antimicrobial up to approximately 12 years of age (Figure 1a). The respiratory MPC was associated with greatest prescription odds compared to the gastroenteric MPC. Mixed practices were associated with significantly increased prescription odds compared to practices treating companion animals only. RCVS accredited practices were less likely to prescribe a systemic antimicrobial.

Systemic HPCIA prescription

Descriptive analyses and univariable model results are summarised in Supplementary material, Table S5. Final multivariable model results are available in Table 3. Vaccinated or insured dogs were less likely to be prescribed a systemic HPCIA. The respiratory MPC showed the greatest odds of prescription. Odds increased with age in dogs (Figure 2a). Compared to the retriever, the toy genetic breed group was associated with the greatest odds of systemic HPCIA prescription.

Topical antimicrobial prescription

Descriptive analyses and univariable model results are summarised in Supplementary material, Table S6. Final multivariable model results are available in Table 4. Insured dogs were less likely to be prescribed a topical antimicrobial, though male, microchipped, or vaccinated dogs displayed significantly increased prescription odds. The effect of age was varied according to MPC; the pruritus MPC was generally associated with greatest prescription odds throughout life, broadly decreasing with increased age (Figure 3a). Compared to the retriever, sight hounds displayed the smallest prescription odds. Practices employing RCVS specialists were less likely to prescribe a topical antimicrobial.

Cats

Antimicrobial prescription

Systemic antimicrobials, topical antimicrobials or systemic HPCIAs were prescribed in 32.9% (CI 31.9-33.8), 6.1% (CI 5.9-6.3) and 17.3% (CI 16.2-18.4) of consultations. The most commonly prescribed systemic HPCIA class were 3rd generation cephalosporins (16.4% of sick consults, CI 15.3-17.6), followed by fluoroquinolones (0.7%, CI 0.4-0.9) and macrolides (0.03%, CI 0.0-0.05). Antimicrobial prescription summarised by commonly consulted breed is summarised in Supplementary material, Table S7.

Systemic antimicrobial prescription

Descriptive analyses and univariable model results are summarised in Supplementary material, Table S8. Final multivariable model results are available in Table 5. Vaccinated or insured cats had significantly reduced odds of systemic antimicrobial prescription. The respiratory and trauma MPCs were associated with greatest prescription odds, though there was a significant interaction between sex and MPC, with male cats significantly more likely to receive a prescription when presenting with trauma than female cats. Female cats were

generally associated with reduced odds until approximately 15 years of age, when females were then associated with increased odds compared to male cats (Figure 1b). Compared to practices treating companion animals only, mixed practices were more likely to prescribe a systemic antimicrobial.

Systemic HPCIA prescription

Descriptive analyses and univariable model results are summarised in Supplementary material, Table S9. Final multivariable model results are available in Table 6. Vaccinated or insured cats were less likely to be prescribed a systemic HPCIA. Though the respiratory MPC showed the greatest odds, RCVS accredited practices were associated with increased odds for cats presenting with trauma. Prescription probability increased up to 6-9 years of age before reducing until approximately 18 years of age and increasing again hereafter; compared to females, males were more likely to be prescribed between 5 and 14 years of age (Figure 2b). Compared to the West Europe genetic breed group, the Asian group was associated with the greatest odds of systemic HPCIA prescription.

Topical antimicrobial prescription

Descriptive analyses and univariable model results are summarised in Supplementary material Table 10. Final multivariable model results are available in Table 7. Insured cats were less likely to be prescribed a topical antimicrobial. The effect of age at consultation varied according to MPC; in pruritic cats there was a decreasing prescription probability until approximately 7 years of age, before increasing again (Figure 3b). Compared to the West Europe genetic breed group, crossbreeds displayed the smallest prescription odds.

Discussion

Here we have demonstrated frequent antimicrobial prescription including systemic HPCIAs (particularly in cats), in veterinary practices in the UK. Considering the importance of HPCIAs in the context of AMR (*35*), we have identified a vital need to understand more about factors potentially driving such prescribing behaviours. We have further augmented EHR data using a range of external data sources to identify key owner, animal and practice-related risk factors associated with systemic and topical antimicrobial, and systemic HPCIA, prescription; such factors potentially informing key antimicrobial stewardship targets of importance to companion animal practice.

Regarding owner care decision-related factors, vaccinated dogs and cats were associated with significantly reduced systemic antimicrobial and HPCIA prescription odds, possibly reflecting perceived or actual reduced risk of antimicrobial-responsive disease in vaccinated animals. Though most companion animal vaccines target viruses, bacterial infection secondary to vaccine-preventable viral disease is documented (*36*). Risk avoidance plays an important role in antimicrobial prescribing practices (*12*), potentially prompting more frequent prescription in unwell, unvaccinated animals. We speculate that previous engagement with preventive healthcare might select for owners more likely to seek veterinary attention earlier and/or to pursue diagnostic options in preference to empirical prescription. Regardless of what might be driving these trends, the O'Neill Report has recommended that promoting development and use of vaccines and alternatives to antibiotics should form a key component of efforts to curtail human AMR dissemination (*37*); our findings suggest that such recommendations should also be considered for companion animals.

Presence of insurance was also associated with decreased systemic and topical antimicrobial prescription odds, potentially highlighting veterinary practitioners being more likely to seek a

wider range of diagnostic options in preference to empirical antibiosis in insured animals. However, insured dogs were also associated with increased systemic HPCIA prescription odds. Cost of therapy has been shown to influence companion animal antimicrobial agent choice (*17*), and HPCIAs are anecdotally considered a more expensive option compared to other antimicrobials. Hence, our findings might reflect increased willingness to prescribe relatively expensive antimicrobials to insured dogs.

Though HPCIA classification remains under debate, HPCIA use has formed a focus for AMR-related policy (*37*). Whilst a number of HPCIA classes (e.g. glycopeptides, which are not authorised for use in animals) are very rarely prescribed to companion animals in the UK (*22*), prescription of fluoroquinolones and 3rd generation cephalosporins (particularly in cats) is relatively commonplace, though current antimicrobial prescribing guidance strongly discourages such practices (*38*).

Considering animal-intrinsic factors, male cats were associated with increased systemic antimicrobial prescription odds in younger animals, though the opposite was found for dogs. Sex-based variation in bacterial infection risk has been previously identified (*39-41*), and cat fight-related injuries are a frequently recorded clinical complaint (*42*) more commonly associated with young outdoor-ranging male cats (*43*). Indeed, here we found male cats presenting with trauma to be more commonly prescribed systemic antimicrobials. Further, time of injury is less likely to be known in outdoor ranging cats compared to dogs; such uncertainty might well prompt a more cautious antimicrobial prescribing approach (*44*).

Other studies have also identified age- or sex-related variation in AMR risk (*39-41*). For instance, Radford et al. (2011) demonstrated decreasing systemic antimicrobial prescription

probability with increased age (*20*), potentially reflecting increased actual or perceived non-communicable disease incidence as animals age. This interpretation might partly explain our findings, though a notable exception was observed - systemic HPCIA prescription. In cats an easy-to-administer (injectable) long-acting 3rd generation cephalosporin formulation is widely used (*21-23*). Although not completely explanatory, our findings may suggest that as an animal ages the owner or veterinary surgeon perceives an increased probability of an animal being refractory to an intervention (e.g. administering oral tablets), increasing the likelihood of a prescriber choosing easy-to-administer formulations. Provision of inappropriate dosages as a result of non-compliance has been previously identified as a key influencer of antimicrobial agent choice (*17*). Deciding whether the AMR risk posed by a possible under-dose of a first-line antimicrobial outweighs the AMR risk posed by the labelled dose of a third-line HPCIA remains an important unanswered question in companion animal practice.

As with humans (*10*,*11*,*13*), respiratory clinical signs were most commonly associated with systemic antimicrobial prescription in dogs and cats. Humans suffering from respiratory conditions are often inappropriately prescribed antimicrobials, the majority of such conditions being viral or non-infectious in origin (*10*). This has also been shown for companion animals, though bacterial sequelae to primary viral disease has been documented (*45*). Considering these shared patterns, although prescribing guidance is available (*46*), we suggest respiratory disease as a pertinent area for further investigation of 'one health' stewardship intervention methods.

The retriever group, containing a number of breeds commonly associated with dermatological disease (*47*), was associated with increased odds of topical antimicrobial prescription. This finding and interpretation is plausible, suggesting that the breed summarisation technique

346 employed here to combat the modelling issues posed by over recorded 250 dog and 50 cat
347 breeds in this dataset was useful. However, it should be remembered that genetic linkage does
348 not necessarily imply phenotypic similarity. As such, individual breed-level phenotypes
349 might be responsible for conferring variant bacterial infection risk in ways not explored, and
350 indeed potentially masked, here. We aim to identify additional means by which breeds can be
351 effectively summarised according to both shared genotype and phenotype for future analyses.
352
353 Although the individual animal accounted for the majority of random effect variance seen
354 here, veterinary-led factors might well yield more readily accessible routes towards
355 stewardship. The voluntary RCVS PSS requires antimicrobial usage policies, infection
356 control plans, and established clinical audit for site accreditation (*48*), and here we observed
357 reduced canine systemic antimicrobial prescription odds in accredited practices. Though
358 practices seeking accreditation might already be more engaged with quality improvement, we
359 would nevertheless recommend further consideration as to whether the RCVS PSS could play
360 a more central role for encouraging stewardship in both first opinion and referral practice.
361
362 Compared to practices only treating companion animals, mixed species practices were
363 associated with increased systemic antimicrobial prescription odds. Veterinary surgeons
364 employed in different sectors express varied attitudes towards AMR (*16*); a finding perhaps
365 demonstrated at scale here. Practices employing RCVS specialists were also associated with
366 reduced topical antimicrobial prescription odds in dogs, potentially reflecting varied case
367 management approach (*49*) or caseload compared to first opinion practices.
368
369 Considering limitations of this study, although we successfully augmented EHRs with a
370 variety of data sources, no dataset is infallible. For instance, the veterinary surgeon

371 employment record of the RCVS Practice Register is updated only on an *ad hoc* basis. It is
372 thus possible that the surveyed veterinary surgeon population varied over the two-year study
373 period in ways not captured here. Veterinary practices participating in SAVSNET are
374 recruited by convenience and might not be representative of the wider UK population.
375 Though no clear associations between IMD or pet population density and prescription were
376 found here, the complexities of summarising IMD across the devolved constituent countries
377 of the UK (*50*), coupled with the relative infancy of pet population demographic studies (*30*),
378 lead us to recommend re-evaluation as research methodologies further mature. The analysed
379 population was relatively skewed towards less deprived areas; to ascertain whether this is
380 reflective of the wider UK pet owning community, including the charity and low-income
381 veterinary sectors in future analyses would be warranted. We would advise caution for
382 inferring causal relationships between factors and outcome variables explored in this cross-
383 sectional study; similarly, group-level observations might have limited relevance to
384 individual animals. More generalised SAVSNET limitations has been previously discussed;
385 briefly, antimicrobial prescription quantification depends on practitioners charging for
386 antimicrobials, and analysed practices were recruited by convenience (*22*,*30*).
387
388 **Conclusions**
389 We have demonstrated the utility of veterinary EHRs collected from a cohort of veterinary
390 practices to identify a range of factors associated with canine and feline antimicrobial
391 prescription. Though factors influencing decision-making remain multifactorial and complex,
392 our findings suggest that gathering clinical evidence surrounding respiratory disease might be
393 of importance to stewardship. Preventive healthcare could also play a valuable stewardship
394 role, and should form the basis of owner-targeted health messaging, as should the RCVS PSS
395 to veterinary practitioners.

Conflict of interest statement

None of the authors of this paper have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of this paper.

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Appendix: Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi: ...

Tables

Table 1: Descriptive demographic summary of sick canine and feline consultations utilised for analyses of factors associated with antimicrobial prescription, gathered from a large sentinel network of UK-based veterinary practices.

Variable	Category	Dogs (*n* = 281,543) % of consults (95% CI [a])	Cats (*n* = 111,139) % of consults (95%
Categorical factors			
Country	England	86.6 (81.4-91.9)	88.6 (83.8-93.5)
	Scotland	6.1 (3.0-9.1)	4.5 (2.1-6.9)
	Wales	7.4 (2.8-12.0)	7.0 (2.1-6.9)
Sex	Male	51.8 (51.3-52.3)	51.8 (51.3-52.4)
Neuter status	Neutered	64.6 (63.3-65.9)	82.8 (81.7-84.0)
Microchip status	Microchipped	54.4 (52.4-56.3)	37.8 (36.0-39.5)
Vaccination status	Vaccinated	70.0 (68.6-71.3)	52.7 (51.2-54.1)
Insurance status	Insured	33.5 (31.1-35.9)	19.3 (17.3-21.3)
Owner urban status	Urban	63.8 (59.5-68.1)	70.2 (66.2-74.2)
Main presenting complaint	Gastroenteric	11.3 (11.0-11.6)	8.3 (8.0-8.7)
	Respiratory	4.0 (3.8-4.1)	5.5 (5.2-5.8)
	Pruritus	18.0 (17.3-18.6)	10.3 (9.9-10.7)
	Trauma	16.8 (16.1-17.5)	17.0 (16.3-17.7)
	Tumour	6.0 (5.8-6.3)	3.9 (3.6-4.1)
	Kidney disease	0.7 (0.6-0.8)	2.9 (2.5-3.2)
	Other unwell	43.3 (42.0-44.6)	52.1 (50.9-53.4)
Practice type	Mixed	22.7 (15.1-30.3)	18.1 (11.6-24.6)
	Companion animal	70.6 (62.4-78.8)	76.0 (68.9-83.1)
	Companion & equine	2.4 (0.7-4.0)	2.3 (0.7-4.0)
	Companion & large	4.3 (0.4-8.2)	3.5 (0.3-6.8)
Accreditation	True	83.9 (77.1-90.6)	83.5 (76.5-90.5)
Hospital status	True	20.2 (14.4-26.0)	20.0 (14.5-25.5)
Referral interest	True	27.9 (20.9-34.9)	27.3 (20.3-34.2)
Employed RCVS AVP [b]	True	24.5 (17.2-31.7)	26.7 (19.2-34.2)
Employed RCVS specialist [b]	True	2.5 (0.8-4.2)	1.9 (0.6-3.1)
Continuous factors			
Age at consultation	Mean	7.1 (7.1-7.2)	9.5 (9.5-9.6)
	Median [min-max]	7.2 [0-22]	9.7 [0-25.9]
Rescaled Indices of multiple deprivation (rIMD) rank	Mean	0.59 (0.59-0.60)	0.60 (0.60-0.61)
	Median [min-max]	0.62 [0.0-1.0]	0.63 [0.0-1.0]
Animals per household [c]	Mean	0.59 (0.59-0.59)	0.50 (0.49-0.50)
	Median [min-max]	0.47 [0-6.0]	0.39 [0-3.6]
Animals per km^2 [c]	Mean	399.4 (397.8-401.0)	409.4 (407.0-411.8)
	Median [min-max]	266 [0-4360]	288 [0-5363]

[a] 95% Confidence interval

[b] At least one employed veterinary surgeon holding Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

[c] Aegerter et al., 2017

Table 2: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial in dogs (n = 72,436/281,543 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	0.57	0.76	Intercept	England	-0.08	0.08	0.93 (0.80-1.08)	-
Site	0.05	0.23		Scotland	-0.06	0.09	0.94 (0.79-1.12)	-
Practice	0.06	0.24		Wales	-0.13	0.09	0.88 (0.73-1.05)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	-0.38	0.06	**0.68 (0.61-0.76)**	**<0.01**
				Other unwell	-0.94	0.02	**0.39 (0.38-0.40)**	**<0.01**
				Pruritus	-0.68	0.02	**0.51 (0.49-0.53)**	**<0.01**
				Respiratory	0.10	0.03	**1.11 (1.06-1.17)**	**<0.01**
				Trauma	-0.89	0.02	**0.41 (0.40-0.43)**	**<0.01**
				Tumour	-1.18	0.03	**0.31 (0.29-0.32)**	**<0.01**
			Neuter status	Not neutered	-	-	1.00	-
				Neutered	-0.11	0.01	**0.90 (0.88-0.92)**	**<0.01**
			Sex	Female	-	-	1.00	-
				Male	-0.03	0.01	**0.97 (0.95-0.99)**	**0.01**
			Vaccination status	Not vaccinated	-	-	1.00	-
				Vaccinated	-0.08	0.01	**0.93 (0.90-0.95)**	**<0.01**
			Insurance status	Not insured	-	-	1.00	-
				Insured	-0.14	0.02	**0.87 (0.84-0.90)**	**<0.01**
			Genetic breed group [e]	Retriever	-	-	1.00	-
				Ancient / spitz	0.25	0.05	**1.28 (1.17-1.40)**	**<0.01**
				Crossbreed	0.06	0.02	**1.06 (1.03-1.10)**	**<0.01**
				Herding	0.14	0.03	**1.15 (1.09-1.22)**	**<0.01**
				Mastiff-like	0.15	0.02	**1.16 (1.11-1.21)**	**<0.01**
				Scent hound	0.10	0.04	**1.11 (1.03-1.19)**	**<0.01**
				Sight hound	0.31	0.04	**1.36 (1.25-1.48)**	**<0.01**
				Small terrier	0.16	0.02	**1.18 (1.13-1.22)**	**<0.01**
				Spaniel	0.16	0.02	**1.17 (1.13-1.22)**	**<0.01**
				Toy	-0.00	0.03	1.00 (0.94-1.05)	0.92
				Unclassified	0.11	0.02	**1.12 (1.07-1.16)**	**<0.01**
				Unknown	0.09	0.05	1.09 (0.99-1.21)	0.075
				Working dog	0.19	0.03	**1.21 (1.15-1.27)**	**<0.01**
			Practice type	Companion animal	-	-	1.00	-
				Mixed	0.14	0.07	**1.15 (1.01-1.30)**	**0.04**
				Companion & equine	-0.05	0.15	0.95 (0.71-1.27)	0.73
				Companion & large	0.13	0.14	1.14 (0.86-1.50)	0.37
			Accreditation status	None	-	-	1.00	-
				1+ accredited site	-0.24	0.08	**0.79 (0.68-0.92)**	**<0.01**
			Referral interest	No	-	-	1.00	-
				Yes	-0.10	0.05	0.91 (0.82-1.00)	0.06
			Continuous factors					
			Age (years)	**Age - linear**	-1.12	0.01	**0.89 (0.87-0.91)**	**<0.01**
				Age - quadratic	-0.09	0.01	**0.92 (0.90-0.93)**	**<0.01**
				Age - cubic	0.05	0.01	**1.05 (1.04-1.07)**	**<0.01**
			Interaction terms					
			Insurance Status : Age (years)	**Insured : Age**	0.08	0.02	**1.09 (1.04-1.14)**	**<0.01**
				Insured : Age -	0.03	0.01	**1.03 (1.00-1.06)**	**0.03**
				Insured : Age - cubic	-0.03	0.01	**0.97 (0.95-1.00)**	**0.02**

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Vonholdt et al., 2010

Table 3: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA in dogs (n = 3,971/281,543 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	3.04	1.74	Intercept	England	-4.77	0.11	0.01 (0.01-0.01)	-
Site	0.13	0.36		Scotland	-4.91	0.21	0.01 (0.01-0.01)	-
Practice	0.44	0.66		Wales	-4.88	0.22	0.01 (0.01-001)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	0.11	0.18	1.12 (0.78-1.60)	0.55
				Other unwell	-0.33	0.06	**0.72 (0.64-0.80)**	**<0.01**
				Pruritus	-0.23	0.07	**0.79 (0.70-0.90)**	**<0.01**
				Respiratory	0.29	0.09	**1.33 (1.13-1.57)**	**<0.01**
				Trauma	-1.16	0.08	**0.31 (0.27-0.37)**	**<0.01**
				Tumour	-0.92	0.11	**0.40 (0.32-0.49)**	**<0.01**
			Vaccination status	Not vaccinated	-	-	1.00	-
				Vaccinated	-0.10	0.04	**0.91 (0.83-0.99)**	**0.03**
			Insurance status	Not insured	-	-	1.00	-
				Insured	0.15	0.05	**1.16 (1.07-1.27)**	**<0.01**
			Genetic breed group [e]	Retriever	-	-	1.00	-
				Ancient / spitz	0.12	0.22	1.13 (0.73-1.74)	0.60
				Crossbreed	0.24	0.08	**1.27 (1.09-1.48)**	**<0.01**
				Herding	0.04	0.12	1.04 (0.82-1.32)	0.73
				Mastiff-like	0.16	0.10	1.17 (0.97-1.43)	0.11
				Scent hound	0.67	0.13	**1.96 (1.52-2.52)**	**<0.01**
				Sight hound	0.43	0.17	**1.54 (1.10-2.15)**	**0.01**
				Small terrier	0.67	0.08	**1.96 (1.67-2.29)**	**<0.01**
				Spaniel	0.45	0.08	**1.57 (1.33-1.84)**	**<0.01**
				Toy	0.94	0.10	**2.56 (2.10-3.12)**	**<0.01**
				Unclassified	0.39	0.09	**1.47 (1.24-1.74)**	**<0.01**
				Unknown	0.23	0.22	1.25 (0.81-1.94)	0.31
				Working dog	0.45	0.11	**1.56 (1.27-1.93)**	**<0.01**
			Continuous factors					
			Age (years)	**Age - linear**	0.19	0.04	**1.21 (1.12-1.31)**	**<0.01**
				Age - quadratic	-0.06	0.03	**0.95 (0.90-0.99)**	**0.03**
				Age - cubic	0.04	0.02	**1.04 (1.01-1.08)**	**0.01**

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Vonholdt et al., 2010

Table 4: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial in dogs (n = 40,030/281,543 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	0.55	0.74	Intercept	England	-4.01	0.07	0.02 (0.02-0.02)	-
Site	0.02	0.14		Scotland	-3.88	0.09	0.02 (0.02-0.02)	-
Practice	0.02	0.16		Wales	-4.06	0.09	0.02 (0.01-0.02)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	0.71	0.22	**2.03 (1.31-3.15)**	**<0.01**
				Other unwell	2.41	0.07	**11.18 (9.78-12.79)**	**<0.01**
				Pruritus	3.24	0.07	**25.64 (22.39-29.35)**	**<0.01**
				Respiratory	0.63	0.11	**1.88 (1.50-2.34)**	**<0.01**
				Trauma	1.35	0.07	**3.87 (3.36-4.46)**	**<0.01**
				Tumour	1.15	0.08	**3.16 (2.68-3.73)**	**<0.01**
			Sex	Female	-	-	1.00	-
				Male	0.07	0.01	**1.08 (1.05-1.10)**	**<0.01**
			Microchip status	Not microchipped	-	-	1.00	-
				Microchipped	0.03	0.01	**1.03 (1.00-1.06)**	**0.02**
			Vaccination status	Not vaccinated	-	-	1.00	-
				Vaccinated	0.08	0.02	**1.08 (1.05-1.11)**	**<0.01**
			Insurance status	Not insured	-	-	1.00	-
				Insured	-0.10	0.02	**0.90 (0.88-0.93)**	**<0.01**
			Genetic breed group [e]	Retriever	-	-	1.00	-
				Ancient / spitz	-0.14	0.06	**0.87 (0.77-0.97)**	**0.02**
				Crossbreed	-0.21	0.02	**0.81 (0.78-0.84)**	**<0.01**
				Herding	-0.57	0.04	**0.57 (0.53-0.61)**	**<0.01**
				Mastiff-like	-0.03	0.03	0.97 (0.93-1.03)	0.32
				Scent hound	-0.25	0.04	**0.78 (0.71-0.85)**	**<0.01**
				Sight hound	-0.92	0.07	**0.40 (0.34-0.46)**	**<0.01**
				Small terrier	-0.29	0.03	**0.75 (0.71-0.79)**	**<0.01**
				Spaniel	0.04	0.02	1.04 (1.00-1.09)	0.08
				Toy	-0.14	0.03	**0.87 (0.82-0.93)**	**<0.01**
				Unclassified	-0.06	0.03	**0.94 (0.89-0.99)**	**0.011**
				Unknown	-0.31	0.06	**0.74 (0.65-0.83)**	**<0.01**
				Working dog	-0.21	0.03	**0.81 (0.76-0.87)**	**<0.01**
			Hospital status	None	-	-	1.00	-
				1+ hospital site	0.06	0.04	1.07 (0.98-1.16)	0.15
			Employed RCVS AVP [f]	None	-	-	1.00	-
				1+ AVP	0.08	0.04	1.08 (0.99-1.17)	0.08
			Employed RCVS specialists [f]	None	-	-	1.00	-
				1+ specialist	-0.27	0.09	**0.77 (0.64-0.92)**	**<0.01**
			Continuous factors					
			Age (years)	Age - linear	-0.10	0.09	0.91 (0.76-1.09)	0.30
				Age - quadratic	0.04	0.04	1.04 (0.98-1.13)	0.39
				Age - cubic	0.04	0.04	1.04 (0.96-1.13)	0.30
			Interaction terms					
			Main presenting complaint : Age (years)	Kidney disease : Age	-0.33	0.27	0.72 (0.42-1.22)	0.22
				Other unwell : Age	-0.30	0.10	**0.74 (0.61-0.89)**	**<0.01**
				Pruritus : Age	0.08	0.10	1.08 (0.89-1.31)	0.42
				Respiratory : Age	-0.01	0.15	0.90 (0.66-1.21)	0.47
				Trauma : Age	0.01	0.10	1.01 (0.82-1.23)	0.95
				Tumour : Age	-0.15	0.12	0.86 (0.69-1.08)	0.20
				Kidney disease : Age - quadratic	0.04	0.15	1.04 (0.77-1.40)	0.79
				Other unwell : Age - quadratic	-0.11	0.05	**0.90 (0.82-0.98)**	**0.02**
				Pruritus : Age - quadratic	-0.00	0.05	1.00 (0.91-1.09)	0.96
				Respiratory : Age - quadratic	-0.12	0.08	0.89 (0.76-1.03)	0.11
				Trauma : Age - quadratic	-0.02	0.05	0.98 (0.89-1.08)	0.68
				Tumour : Age - quadratic	0.14	0.06	**1.15 (1.02-1.29)**	**0.02**
				Kidney disease : Age - cubic	-0.01	0.11	0.99 (0.79-1.24)	0.94
				Other unwell : Age - cubic	-0.04	0.04	0.97 (0.89-1.05)	0.39
				Pruritus : Age - cubic	-0.06	0.04	0.94 (0.87-1.02)	0.15
				Respiratory : Age - cubic	-0.01	0.07	0.99 (0.86-1.13)	0.84
				Trauma : Age - cubic	-0.03	0.05	0.97 (0.89-1.06)	0.56
				Tumour : Age - cubic	-0.02	0.05	0.98 (0.88-1.08)	0.64

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Vonholdt et al., 2010
[f] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner and / or specialist status

Table 5: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial in cats (n = 36,521/111,139 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	0.50	0.70	Intercept	England	-0.81	0.06	0.45 (0.39-0.50)	-
Site	0.06	0.25		Scotland	-0.77	0.10	0.46 (0.38-0.57)	-
Practice	0.08	0.28		Wales	-0.55	0.12	0.58 (0.46-0.72)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	-0.20	0.07	**0.82 (0.71-0.94)**	**0.01**
				Other unwell	-0.23	0.04	**0.79 (0.73-0.85)**	**<0.01**
				Pruritus	-0.37	0.05	**0.69 (0.63-0.76)**	**<0.01**
				Respiratory	0.91	0.06	**2.48 (2.23-2.77)**	**<0.01**
				Trauma	0.59	0.04	**1.80 (1.65-1.97)**	**<0.01**
				Tumour	-0.56	0.07	**0.57 (0.50-0.65)**	**<0.01**
			Sex	Female	-	-	1.00	-
				Male	0.03	0.05	1.03 (0.93-1.14)	0.59
			Vaccination status	Not vaccinated	-	-	1.00	-
				Vaccinated	-0.09	0.02	**0.92 (0.89-0.95)**	**<0.01**
			Insurance status	Not insured	-	-	1.00	-
				Insured	-0.19	0.02	**0.82 (0.79-0.86)**	**<0.01**
			Genetic breed group [e]	West Europe	-	-	1.00	-
				Asian	0.20	0.05	**1.22 (1.10-1.36)**	**<0.01**
				Crossbreed	0.14	0.03	**1.16 (1.08-1.23)**	**<0.01**
				Mediterranean	0.36	0.26	1.43 (0.86-2.38)	0.17
				Unclassified	0.11	0.06	1.11 (0.99-1.24)	0.07
				Unknown	0.13	0.05	**1.14 (1.03-1.26)**	**0.01**
			Practice type	Companion animal	-	-	1.00	-
				Mixed	0.18	0.08	**1.20 (1.03-1.39)**	**0.02**
				Companion & equine	-0.01	0.18	1.00 (0.70-1.41)	0.98
				Companion & large	0.10	0.17	1.10 (0.80-1.53)	0.56
			Referral interest	No	-	-	1.00	-
				Yes	-0.08	0.06	0.92 (0.82-1.04)	0.18
			Employed RCVS AVP [f]	None	-	-	1.00	-
				1+ AVP	-0.10	0.07	0.90 (0.79-1.04)	0.16
			Continuous factors					
			Age (years)	**Age - linear**	-0.38	0.02	**0.69 (0.66-0.72)**	**<0.01**
				Age - quadratic	-0.08	0.01	**0.90 (0.90-0.95)**	**<0.01**
				Age - cubic	0.10	0.01	**1.08 (1.08-1.12)**	**<0.01**
			Cats per km^2 [g]	**Cats per km² - linear**	-0.02	0.01	**0.98 (0.97-1.00)**	**0.02**
			Interaction terms					
			Sex : Age (years)	**Male : Age**	-0.10	0.03	**0.91 (0.85-0.97)**	**<0.01**
				Male : Age -	-0.10	0.02	**0.91 (0.88-0.94)**	**<0.01**
				Male : Age - cubic	0.03	0.02	1.03 (1.00-1.06)	0.11
			Sex : Main presenting complaint	**Male : Kidney**	-0.26	0.11	**0.77 (0.62-0.96)**	**0.02**
				Male : Other unwell	0.17	0.05	**1.19 (1.07-1.32)**	**<0.01**
				Male : Pruritus	0.10	0.07	1.10 (0.96-1.26)	0.16
				Male : Respiratory	0.06	0.08	1.06 (0.91-1.23)	0.44
				Male : Trauma	0.48	0.06	**1.62 (1.44-1.82)**	**<0.01**
				Male : Tumour	0.15	0.10	1.16 (0.96-1.40)	0.12

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Lipinski et al, 2008
[f] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner and / or specialist status
[g] Aegerter et al., 2017

Table 6: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA in cats (n = 19,018/111,139 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	0.68	0.82	Intercept	England	-2.79	0.21	0.06 (0.04-0.09)	-
Site	0.13	0.36		Scotland	-2.74	0.24	0.07 (0.04-0.10)	-
Practice	0.44	0.66		Wales	-2.55	0.24	0.08 (0.05-0.12)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	0.55	0.25	**1.74 (1.08-2.82)**	**0.02**
				Other unwell	0.59	0.12	**1.80 (1.43-2.26)**	**<0.01**
				Pruritus	1.08	0.13	**2.95 (2.28-3.81)**	**<0.01**
				Respiratory	1.50	0.14	**4.47 (3.41-5.85)**	**<0.01**
				Trauma	1.06	0.12	**2.89 (2.27-3.67)**	**<0.01**
				Tumour	0.38	0.18	**1.46 (1.04-2.03)**	**0.03**
			Sex	Female	-	-	1.00	-
				Male	0.12	0.03	**1.13 (1.07-1.19)**	**<0.01**
			Vaccination status	Not vaccinated	-	-	1.00	-
				Vaccinated	-0.06	0.02	**0.95 (0.91-0.98)**	**<0.01**
			Insurance status	Not insured	-	-	1.00	-
				Insured	-0.14	0.03	**0.87 (0.83-0.92)**	**<0.01**
			Owner urban status	Urban	-	-	1.00	-
				Rural	0.05	0.03	1.05 (1.00-1.11)	0.06
			Genetic breed group [e]	West Europe	-	-	1.00	-
				Asian	0.21	0.07	**1.23 (1.08-1.40)**	**<0.01**
				Crossbreed	0.14	0.04	**1.16 (1.06-1.26)**	**<0.01**
				Mediterranean	0.11	0.32	1.12 (0.59-2.11)	0.73
				Unclassified	0.14	0.07	1.15 (1.00-1.33)	0.06
				Unknown	0.12	0.06	1.12 (0.99-1.27)	0.07
			Accreditation status	Not accredited	-	-	1.00	-
				1+ accredited site	0.10	0.22	1.10 (0.72-1.69)	0.65
			Continuous factors					
			Age (years)	**Age - linear**	-0.23	0.03	**0.80 (0.76-0.85)**	**<0.01**
				Age - quadratic	-0.13	0.02	**0.88 (0.85-0.90)**	**<0.01**
				Age - cubic	0.13	0.01	**1.14 (1.11-1.17)**	**<0.01**
			Interaction terms					
			Main presenting complaint : Accreditation	Kidney disease : accredited site	0.23	0.26	1.26 (0.76-2.08)	0.37
				Other unwell : accredited site	0.21	0.13	1.23 (0.96-1.58)	0.10
				Pruritus : accredited site	0.00	0.14	1.00 (0.76-1.32)	1.00
				Respiratory : accredited site	0.23	0.15	1.26 (0.94-1.69)	0.12
				Trauma : accredited site	0.64	0.13	**1.90 (1.46-2.47)**	**<0.01**
				Tumour : accredited site	0.19	0.19	1.21 (0.83-1.75)	0.32
			Sex : Age (years)	Male : Age - linear	-0.06	0.04	0.95 (0.87-1.02)	0.17
				Male : Age - quadratic	-0.09	0.02	**0.91 (0.87-0.95)**	**<0.01**
				Male : Age - cubic	0.02	0.02	1.02 (0.98-1.06)	0.32

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Lipinski et al, 2008

Table 7: Results from a multivariable mixed effect logistic regression model assessing the association between a range of categorical animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial in cats (n = 6,769/111,139 sick consultations). Significant (P<0.05) results are displayed in bold.

Random effect	Variance	SD [a]	Variable	Category	β	SE [b]	OR [c] (CI [d])	*P*
Animal	0.82	0.90	Intercept	England	-3.98	0.17	0.02 (0.01-0.03)	-
Site	0.02	0.15		Scotland	-3.94	0.19	0.02 (0.01-0.03)	-
Practice	0.03	0.16		Wales	-3.91	0.19	0.02 (0.01-0.03)	-
			Categorical factors					
			Main presenting complaint	Gastroenteric	-	-	1.00	-
				Kidney disease	-0.98	0.50	0.38 (0.14-1.00)	0.05
				Other unwell	1.79	0.16	**5.96 (4.37-8.12)**	**<0.01**
				Pruritus	2.13	0.16	**8.37 (6.09-11.51)**	**<0.01**
				Respiratory	1.21	0.18	**3.36 (2.35-4.82)**	**<0.01**
				Trauma	1.34	0.17	**3.82 (2.76-5.28)**	**<0.01**
				Tumour	0.38	0.25	1.46 (0.90-2.36)	0.12
			Sex	Female	-	-	1.00	-
				Male	0.05	0.03	1.05 (1.00-1.11)	0.06
			Neutered status	Not neutered	-	-	1.00	-
				Neutered	-0.06	0.04	0.94 (0.88-1.01)	0.09
			Insurance status	Not insured	-	-	1.00	-
				Insured	-0.13	0.04	**0.88 (0.82-0.95)**	**<0.01**
			Genetic breed group [e]	West Europe	-	-	1.00	-
				Asian	-0.14	0.09	0.87 (0.73-1.03)	0.09
				Crossbreed	-0.50	0.05	**0.61 (0.55-0.67)**	**<0.01**
				Mediterranean	-0.40	0.50	0.67 (0.25-1.78)	0.42
				Unclassified	-0.24	0.09	**0.79 (0.66-0.95)**	**0.01**
				Unknown	-0.43	0.08	**0.65 (0.56-0.77)**	**<0.01**
			Referral interest	No	-	-	1.00	-
				Yes	0.08	0.05	1.08 (0.98-1.19)	0.11
			Continuous factors					
			Age (years)	Age - linear	0.08	0.26	1.09 (0.65-1.82)	0.75
				Age - quadratic	-0.12	0.14	0.89 (0.68-1.17)	0.40
				Age - cubic	-0.14	0.14	0.87 (0.66-1.15)	0.34
			Interaction terms					
			Main presenting complaint : Age (years)	Kidney disease : Age	1.14	0.68	3.11 (0.82-11.84)	0.10
				Other unwell : Age	-0.61	0.27	**0.54 (0.32-0.91)**	**0.02**
				Pruritus : Age	0.18	0.27	1.19 (0.70-2.03)	0.52
				Respiratory : Age	-0.34	0.31	0.71 (0.39-1.29)	0.26
				Trauma : Age	0.07	0.28	1.07 (0.62-1.85)	0.81
				Tumour : Age	-0.07	0.38	0.93 (0.44-1.95)	0.85
				Kidney disease : Age - quadratic	0.52	0.32	1.69 (0.89-3.18)	0.11
				Other unwell : Age - quadratic	0.16	0.14	1.17 (0.89-1.53)	0.26
				Pruritus : Age - quadratic	0.42	0.14	**1.52 (1.15-2.02)**	**<0.01**
				Respiratory : Age - quadratic	0.26	0.16	1.29 (0.95-1.77)	0.11
				Trauma : Age - quadratic	0.22	0.15	1.24 (0.93-1.65)	0.14
				Tumour : Age - quadratic	0.16	0.20	1.18 (0.80-1.73)	0.41
				Kidney disease : Age - cubic	-0.51	0.33	0.60 (0.31-1.16)	0.13
				Other unwell : Age - cubic	0.14	0.14	1.15 (0.87-1.52)	0.33
				Pruritus : Age - cubic	0.04	0.15	1.04 (0.78-1.38)	0.81
				Respiratory : Age - cubic	-0.03	0.16	0.97 (0.70-1.33)	0.84
				Trauma : Age - cubic	0.06	0.15	1.06 (0.79-1.42)	0.70
				Tumour : Age - cubic	0.10	0.19	1.10 (0.75-1.61)	0.62

[a] Standard deviation
[b] Standard error
[c] Odds ratio
[d] 95% Confidence interval
[e] Lipinski et al, 2008

Figure legends

Figure 1: Results from two multivariable mixed effect logistic regression models, modelling predicted probability of systemic antimicrobial prescription in sick (a) dogs and (b) cats against age of the animal at time of consultation, in years. For dogs an interaction term considering current insurance status has been included, in cats an interaction term considering sex has been included. Lines refer to predicted probability, with shading relating to 95% confidence intervals to such predictions. Points and triangles are plotted to show original data points expressing the percentage of animals of each relevant age group (rounded to 0.5-year groups) that were prescribed a systemic antimicrobial in the dataset analysed.

Figure 2: Results from two multivariable mixed effect logistic regression models, modelling predicted probability of systemic highest priority critically important antimicrobial (HPCIA) prescription in sick (a) dogs and (b) cats against age of the animal at time of consultation, in years. For cats an interaction term considering sex has been included. Lines refer to predicted probability, with shading relating to 95% confidence intervals to such predictions. Points and triangles are plotted to show original data points expressing the percentage of animals of each relevant age group (rounded to 0.5-year groups) that were prescribed a systemic HPCIA in the dataset analysed.

Figure 3: Results from two multivariable mixed effect logistic regression models, modelling predicted probability of topical antimicrobial prescription in sick (a) dogs and (b) cats against age of the animal at time of consultation, in years. For both species an interaction term considering main presenting complaint has been included. Lines refer to predicted probability, with shading relating to 95% confidence intervals to such predictions. Points are plotted to show original data points expressing the percentage of animals of each relevant age group

503 (rounded to 0.5-year groups) that were prescribed a topical antimicrobial in the dataset
504 analysed.

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Figures

Figure 1

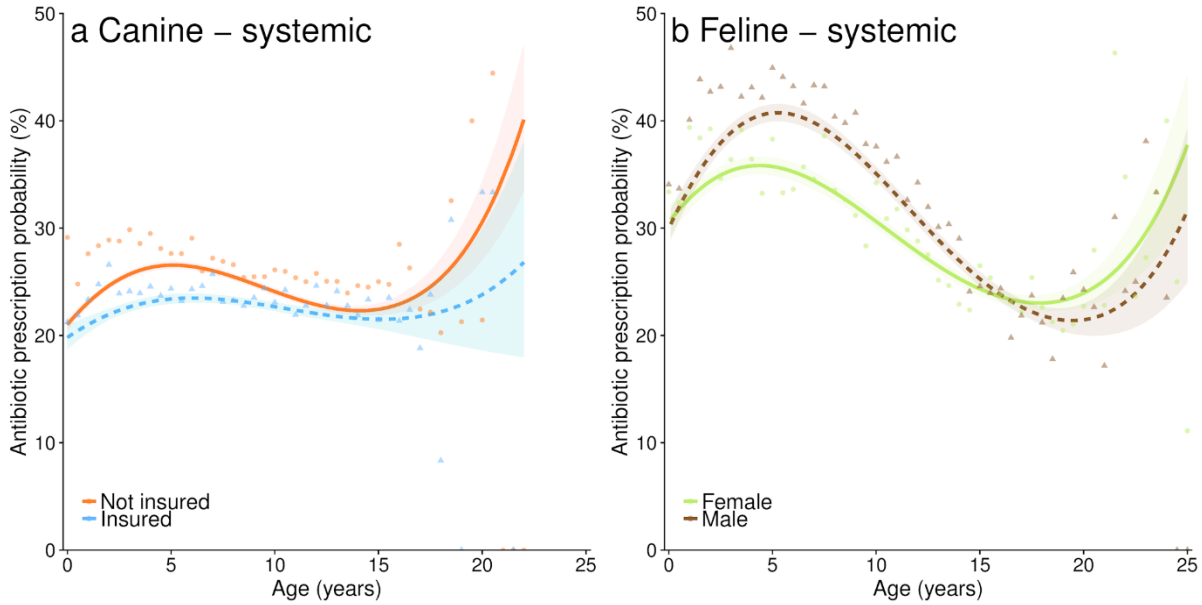


Figure 2

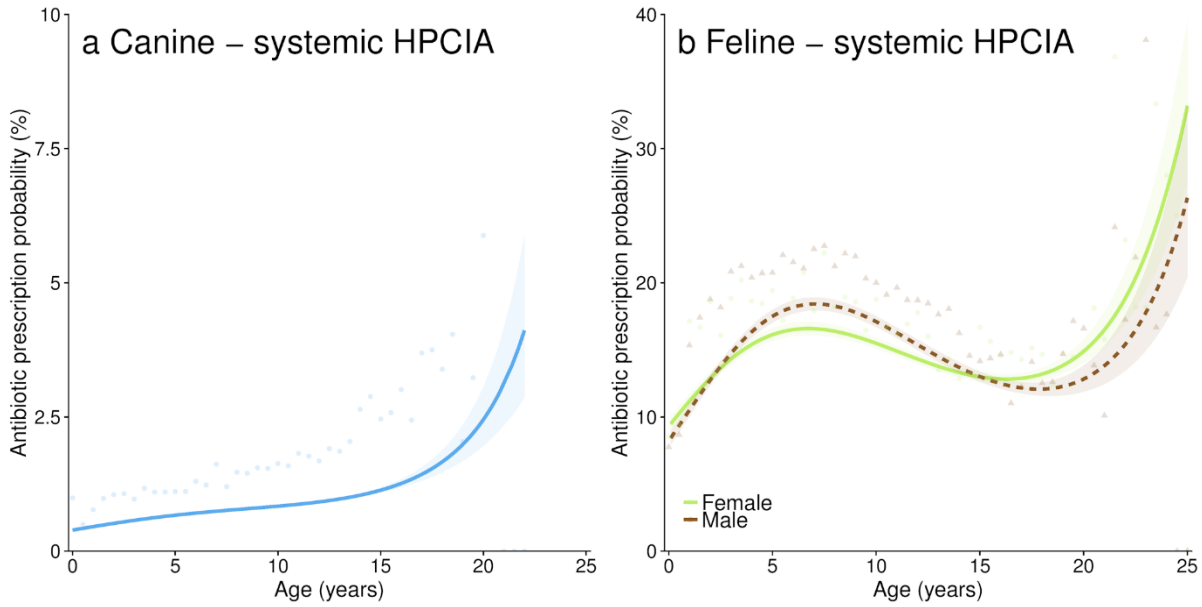
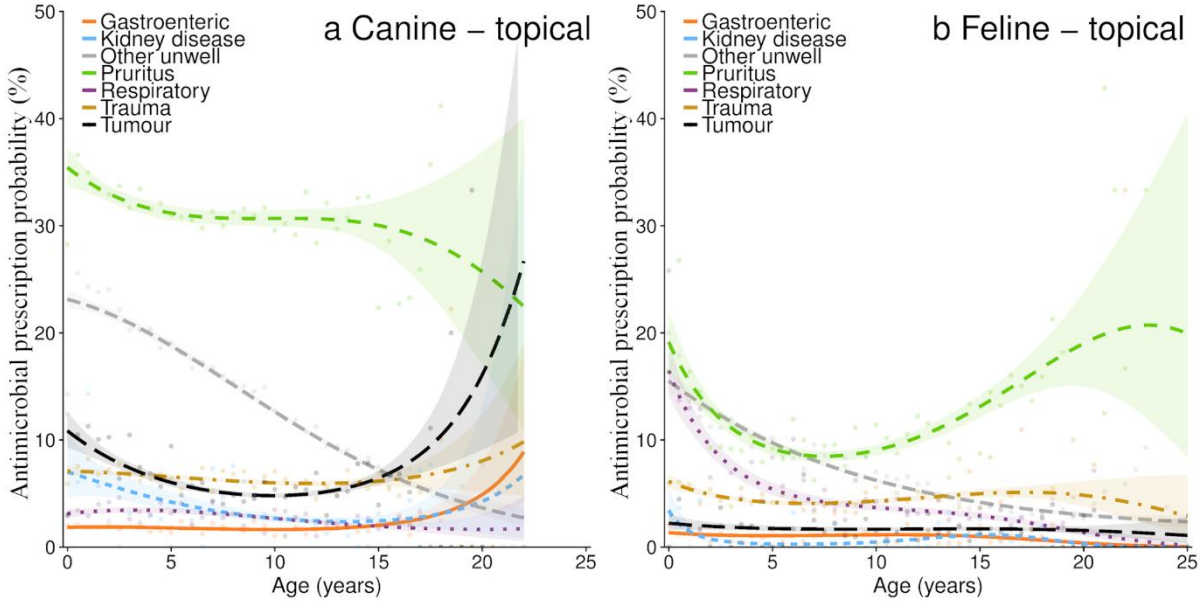


Figure 3


a Canine – topical
b Feline – topical
Gastroenteric
Kidney disease
Other unwell
Pruritus
Respiratory
Trauma
Tumour
Antimicrobial prescription probability (%)
Age (years)
0
10
20
30
40
50
0
5
10
15
20
25

Supplementary material
Table S1

Summary of antimicrobial agents authorised for use in dogs and/or cats in the United Kingdom. Information source: Veterinary Medicines Directorate (https://www.vmd.defra.gov.uk/ProductInformationDatabase/), accessed 1 April 2016.

Antimicrobial class	Antimicrobial agent
Aminoglycoside	Framycetin sulphate
	Gentamicin
	Neomycin
	Streptomycin sulphate
Amphenicol	Florfenicol
Beta-lactam	
Amoxicillin	Amoxicillin
Ampicillin	Ampicillin
Clavulanic acid potentiated amoxicillin	Amoxicillin-clavulanic acid
Cloxacillin	Cloxacillin
1st generation cephalosporin	Cefalexin
3rd generation cephalosporin	Cefovecin
Penicillin	Benzathine benzyl penicillin
Penicillin	Procaine benzylpenicillin
Fluoroquinolone	Enrofloxacin
	Orbifloxacin
	Marbofloxacin
	Pradofloxacin
Fusidic acid	Fusidic acid
Lincosamide	Clindamycin
	Lincomycin
Nitroimidazole	Metronidazole
Nitroimidazole-macrolide	Metronidazole-spiramycin
Potentiated sulphonamide	Sulfadiazine-trimethoprim
Polymyxin	Polymyxin B sulphate
Tetracycline	Doxycycline
	Oxytetracycline

Table S2

Descriptive demographic summary of sick canine and feline consultations utilised for analyses of factors associated with antimicrobial prescription, focusing on the percentage of consultations contributed by a range of genetically similar breed groups, as defined by Vonholdt et al. (2010) for dog breeds, and Lipinski et al. (2008) for cat breeds.

Breeds	**% of consults (CI [a])**	**Breeds**	**% of consults (CI [a])**
Dog breed group		Cat breed group	
Ancient / spitz	1.3 (1.2-1.4)	Asian	3.5 (3.3-3.8)
Crossbreed	22.1 (21.4-22.8)	Crossbreed	87.6 (86.3-88.8)
Herding	4.7 (4.4-5.1)	Mediterranean	0.1 (0.1-0.1)
Mastiff-like	9.5 (9.1-9.9)	West Europe	6.4 (5.3-7.5)
Retriever	14.5 (13.8-15.2)	Unclassified	2.5 (2.3-2.7)
Scent hound	2.6 (2.5-2.8)	Unknown / missing	4.0 (3.1-4.8)
Sight hound	1.6 (1.5-1.8)		
Small terriers	12.8 (12.4-13.2)		
Spaniel	13.7 (13.3-14.1)		
Toy	4.7 (4.4-5.0)		
Working dog	5.2 (5.0-5.4)		
Unclassified	11.3 (10.9-11.6)		
Unknown / missing	1.2 (1.0-1.4)		

[a] 95% Confidence interval

Table S3

Descriptive summary of the percentage of total sick canine consultations where an animal was prescribed at least one antimicrobial (systemic, topical or systemic highest priority critically important (HPCIA) compared against animal breed, including breeds where in excess of 2,500 consultations were recorded.

Genetic breed group	Dog breed	*n* consults	Systemic		Topical		Systemic HPCIA	
			% [b]	95% CI [c]	%	95% CI	%	95% CI
Crossbreed	Crossbreed	59,010	**24.9**	23.9-25.8	**13.3**	12.9-13.7	**1.2**	0.9-1.4
Herding	Border collie	9,821	**26.7**	25.2-28.2	**8.1**	7.5-8.7	**1.0**	0.6-1.5
	Border terrier	5,225	**24.3**	22.6-26.1	**16.0**	14.7-17.3	**1.4**	0.9-1.8
Mastiff-like	Boxer	4,780	**22.6**	21.0-24.2	**17.7**	16.4-19.1	**0.7**	0.4-0.9
	Bulldog	2,530	**32.7**	30.5-34.9	**23.3**	21.3-25.3	**1.1**	0.6-1.6
	Staffordshire bull terrier	9,719	**24.8**	23.6-26.0	**15.6**	14.8-16.5	**0.7**	0.5-1.0
Retriever	Golden retriever	6,223	**26.3**	24.4-28.1	**15.1**	13.9-16.4	**1.0**	0.7-1.4
	Labrador retriever	30,977	**22.7**	21.6-23.8	**15.2**	14.5-15.9	**1.0**	0.7-1.2
Scent hound	Dachshund	3,065	**25.1**	22.7-27.4	**9.6**	8.4-10.9	**2.7**	1.8-3.5
Small terrier	Jack russell terrier	14,869	**26.1**	24.9-27.4	**16.7**	15.8-17.7	**1.4**	1.1-1.8
	West highland white terrier	11,040	**28.9**	27.5-30.3	**10.8**	10.0-11.7	**2.9**	2.4-3.5
	Yorkshire terrier	6,328	**27.6**	25.9-29.2	**11.0**	10.4-11.6	**3.2**	2.6-3.8
Spaniel	Cavalier King Charles	7,586	**22.5**	21.1-24.0	**14.0**	13.1-14.9	**1.3**	0.9-1.7
	Cocker spaniel	15,312	**27.8**	26.5-29.2	**18.1**	17.2-18.9	**1.7**	1.4-2.1
	English springer spaniel	6,774	**26.3**	24.8-27.9	**14.1**	13.1-15.2	**1.3**	0.9-1.7
	Springer spaniel	4,073	**27.4**	25.6-29.2	**15.5**	14.1-16.8	**1.4**	0.9-1.9
Toy	Chihuahua	2,583	**26.5**	24.3-28.8	**7.9**	6.8-9.0	**2.3**	1.5-3.1
	Pug	2,679	**24.7**	22.6-26.7	**21.5**	19.9-23.1	**1.8**	1.1-2.4
	Shih tzu	5,938	**23.4**	21.8-25.0	**17.3**	16.2-18.5	**2.0**	1.6-2.5
Unclassified	Bichon frise	3,314	**25.8**	24.2-27.4	**18.7**	17.1-20.4	**1.4**	0.9-1.8
	Lhasa apso	3,060	**26.5**	24.3-28.7	**17.3**	15.5-19.1	**2.4**	1.7-3.1
Unknown	Unknown	3,182	**24.3**	22.5-26.1	**12.1**	10.8-13.3	**0.9**	0.5-1.3
Working dog	German shepherd dog	6,695	**28.4**	27.0-29.8	**13.5**	12.5-14.4	**1.1**	0.7-1.6
	Schnauzer	3,376	**27.2**	25.2-29.1	**12.3**	11.0-13.5	**1.2**	0.7-1.8

[a] Vonholdt et al., 2010
[b] Percentage of consultations where at least one antimicrobial was prescribed
[c] 95% Confidence Interval
[d] Highest priority critically important antimicrobial

Table S4

Descriptive summary of the percentage of total sick canine consultations prescribed a systemic antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [b]	OR [c]	CI	*P*
Categorical factors							
Country	England (Intercept)	25.7 (24.7-26.7)	-1.16	0.03	**0.31**	0.30-0.33	
	Scotland	26.8 (24.9-28.7)	0.04	0.05	**1.04**	0.94-1.16	0.45
	Wales	24.7 (22.3-27.1)	-0.02	0.07	**0.98**	0.86-1.12	0.76
Main presenting complaint	Gastroenteric (Intercept)	40.2 (41.0-44.8)	-0.46	0.03	**0.63**	0.59-0.67	
	Other unwell	22.0 (21.3-22.8)	-0.93	0.02	**0.34**	0.38-0.41	<0.01
	Kidney disease	30.1 (27.4-32.8)	-0.39	0.06	**0.68**	0.61-0.76	<0.01
	Pruritus	27.0 (25.7-28.4)	-0.65	0.02	**0.52**	0.51-0.54	<0.01
	Respiratory	42.9 (41.0-44.8)	0.11	0.03	**1.12**	1.06-1.17	<0.01
	Trauma	22.5 (21.5-23.6)	-0.86	0.02	**0.42**	0.41-0.44	<0.01
	Tumour	18.4 (17.5-19.3)	-1.17	0.03	**0.31**	0.30-0.33	<0.01
Sex	Female (Intercept)	25.9 (24.9-26.8)	-1.15	0.03	**0.32**	0.30-0.33	
	Male	25.6 (24.7-26.4)	-0.01	0.01	**0.99**	0.97-1.01	0.19
Neuter	Un-neutered (Intercept)	27.4 (26.5-28.2)	-1.08	0.03	**0.34**	0.32-0.36	
	Neutered	24.8 (24.0-25.7)	-0.12	0.01	**0.89**	0.87-0.91	<0.01
Microchip status	Un-microchipped (Intercept)	26.4 (25.5-27.3)	-1.14	0.03	**0.32**	0.30-0.34	
	Microchipped	25.2 (24.3-26.1)	-0.03	0.01	**0.97**	0.95-0.99	0.01
Vaccination status	Un-vaccinated (Intercept)	27.3 (26.4-28.2)	-1.10	0.03	**0.33**	0.32-0.35	
	Vaccinated	25.1 (24.2-26.0)	-0.09	0.01	**0.92**	0.90-0.94	<0.01
Insurance status	Un-insured (Intercept)	26.7 (25.9-27.6)	-1.11	0.03	**0.33**	0.31-0.35	
	Insured	23.7 (22.7-24.7)	-0.14	0.01	**0.87**	0.85-0.89	<0.01
Owner urban status	Urban (Intercept)	25.5 (24.5-26.4)	-1.16	0.03	**0.31**	0.30-0.33	
	Rural	26.2 (25.0-27.3)	0.01	0.01	**1.01**	0.98-1.03	0.71
Genetic breed group [d]	Retriever (Intercept)	23.4 (22.3-24.5)	-1.28	0.03	**0.28**	0.26-0.29	
	Crossbreed	24.9 (23.9-25.8)	0.08	0.02	**1.08**	1.05-1.12	<0.01
	Ancient / spitz	28.8 (26.7-30.8)	0.27	0.05	**1.32**	1.20-1.44	<0.01
	Herding	26.5 (25.2-27.8)	0.14	0.03	**1.15**	1.09-1.22	<0.01
	Mastiff-like	26.2 (25.2-27.1)	0.16	0.02	**1.17**	1.12-1.22	<0.01
	Scent hound	25.6 (24.0-27.1)	0.13	0.04	**1.13**	1.06-1.21	<0.01
	Sight hound	29.5 (27.6-31.5)	0.30	0.04	**1.35**	1.25-1.47	<0.01
	Small terrier	27.3 (26.2-28.4)	0.20	0.02	**1.22**	1.17-1.27	<0.01
	Spaniel	26.5 (25.4-27.5)	0.16	0.02	**1.17**	1.13-1.22	<0.01
	Toy	24.7 (23.4-25.9)	0.06	0.03	**1.06**	1.01-1.12	0.03
	Unclassified	26.0 (25.0-27.0)	0.13	0.02	**1.14**	1.09-1.19	<0.01
	Unknown	24.3 (22.6-26.1)	0.12	0.05	**1.13**	1.03-1.24	0.01
	Working dog	27.4 (26.4-28.4)	0.21	0.03	**1.24**	1.18-1.30	<0.01
Practice type	Small animal (Intercept)	25.4 (24.3-26.4)	-1.19	0.03	**0.31**	0.29-0.32	
	Mixed	26.6 (25.0-28.3)	0.16	0.07	**1.18**	1.03-1.34	0.02
	Small & equine	23.1 (20.2-25.9)	-0.04	0.15	**0.96**	0.71-1.30	0.79
	Small & large	28.7 (26.2-31.2)	0.16	0.14	**1.17**	0.89-1.55	0.27
Accreditation	Not accredited (Intercept)	28.4 (26.3-30.5)	-0.93	0.07	**0.40**	0.35-0.46	
	1+ accredited site	25.2 (24.3-26.1)	-0.27	0.07	**0.77**	0.66-0.89	<0.01
Hospital status	No hospital site (Intercept)	26.2 (25.2-27.2)	-1.14	0.03	**0.32**	0.30-0.34	
	1+ hospital site	23.9 (22.7-25.1)	-0.09	0.06	**0.91**	0.81-1.04	0.16
Referral interest	No (Intercept)	26.0 (25.1-26.9)	-1.12	0.03	**0.33**	0.31-0.35	
	Yes	25.1 (23.2-26.9)	-0.11	0.05	**0.89**	0.80-0.99	0.04
Employed RCVS AVP [e]	None (Intercept)	26.3 (25.3-27.2)	-1.13	0.03	**0.32**	0.31-0.34	
	1+ AVP	24.0 (22.2-25.8)	-0.14	0.06	**0.87**	0.77-0.98	0.02
Employed RCVS specialist [e]	None (Intercept)	25.8 (25.0-26.7)	-1.15	0.03	**0.32**	0.30-0.33	
	1+ specialist	22.0 (19.1-24.8)	-0.18	0.15	**0.84**	0.63-1.11	0.21
Continuous factors							
Age (years)	Intercept		-1.14	0.03	**0.32**	0.31-0.34	
	Age - linear		-0.10	0.01	**0.90**	0.88-0.92	<0.01
	Age - quadratic		-0.03	0.01	**0.97**	0.96-0.99	<0.01
	Age - cubic		0.02	0.01	**1.02**	1.02-1.03	<0.01
rIMD [f]	Intercept		-1.16	0.03	**0.31**	0.30-0.33	
	rIMD		-0.02	0.01	**0.98**	0.97-1.00	0.04
Dogs per household [g]	Intercept		-1.16	0.03	**0.31**	0.30-0.33	
	Dogs per household		-0.01	0.01	**0.99**	0.98-1.01	0.24
Dogs per km^2 [g]	Intercept		-1.16	0.03	**0.31**	0.30-0.33	
	Dogs per km		-0.01	0.01	**1.00**	0.98-1.01	0.34

[a] 95% Confidence Interval
[b] Standard Error
[c] Odds Ratio

[d] Vonholdt et al., 2010
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived
[g] Aegerter et al., 2017

Table S5

Descriptive summary of the percentage of total sick canine consultations prescribed a systemic highest priority critically important antimicrobial (HPCIA). Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [b]	OR [c]	CI	*P*
Categorical factors							
Country	England (Intercept)	1.4 (1.2-1.7)	-4.80	0.07	**0.01**	0.01-0.01	1
	Scotland	1.4 (0.9-1.8)	-0.15	0.19	**0.86**	0.59-1.24	0.42
	Wales	1.1 (0.7-1.6)	-0.11	0.20	**0.90**	0.61-1.32	0.59
Main presenting complaint	Gastroenteric (Intercept)	1.7 (0.8-2.7)	-4.54	0.08	**0.01**	0.01-0.01	
	Kidney disease	2.2 (1.5-2.8)	0.31	0.18	**1.36**	0.95-1.95	0.09
	Other unwell	1.5 (1.3-1.8)	-0.21	0.06	**0.81**	0.73-0.91	<0.01
	Pruritus	1.6 (1.3-1.8)	-0.18	0.07	**0.84**	0.74-0.95	<0.01
	Respiratory	2.8 (2.4-3.3)	0.44	0.08	**1.55**	1.31-1.82	<0.01
	Trauma	0.5 (0.4-0.7)	-1.13	0.08	**0.32**	0.27-0.38	<0.01
	Tumour	0.8 (0.6-1.0)	-0.80	0.11	**0.45**	0.37-0.56	<0.01
Sex	Female (Intercept)	1.4 (1.2-1.7)	-4.80	0.07	**0.01**	0.01-0.01	
	Male	1.4 (1.2-1.6)	-0.03	0.04	**0.97**	0.90-1.05	0.47
Neuter status	Un-neutered (Intercept)	1.4 (1.2-1.6)	-4.82	0.07	**0.01**	0.01-0.01	
	Neutered	1.4 (1.2-1.7)	0.00	0.04	**1.00**	0.92-1.09	0.94
Microchip status	Un-microchipped (Intercept)	1.5 (1.3-1.7)	-4.75	0.07	**0.01**	0.01-0.01	
	Microchipped	1.4 (1.1-1.6)	-0.12	0.04	**0.88**	0.82-0.96	<0.01
Vaccination status	Un-vaccinated (Intercept)	1.5 (1.3-1.7)	-4.73	0.07	**0.01**	0.01-0.01	
	Vaccinated	1.4 (1.2-1.6)	-0.13	0.04	**0.88**	0.81-0.96	<0.01
Insurance status	Un-insured (Intercept)	1.3 (1.1-1.6)	-4.86	0.07	**0.01**	0.01-0.01	
	Insured	1.5 (1.3-1.8)	0.13	0.04	**1.13**	1.04-1.23	<0.01
Owner urban status	Urban (Intercept)	1.3 (1.1-1.5)	-4.83	0.07	**0.01**	0.01-0.01	
	Rural	1.6 (1.3-2.0)	0.03	0.05	**1.04**	0.95-1.14	0.49
Genetic breed group [d]	Retriever (Intercept)	1.0 (0.7-1.2)	-5.19	0.09	**0.01**	0.01-0.01	
	Crossbreed	1.2 (0.9-1.4)	0.06	0.22	**1.07**	0.69-1.64	0.78
	Ancient / spitz	0.9 (0.5-1.3)	0.24	0.08	**1.27**	1.09-1.47	<0.01
	Herding	1.2 (0.7-1.6)	0.08	0.12	**1.09**	0.86-1.37	0.50
	Mastiff-like	1.0 (0.8-1.1)	0.09	0.10	**1.09**	0.90-1.33	0.37
	Scent hound	1.9 (1.4-2.4)	0.67	0.13	**1.95**	1.52-2.51	<0.01
	Sight hound	1.4 (0.9-1.8)	0.34	0.17	**1.41**	1.01-1.97	0.04
	Small terrier	2.3 (1.9-2.6)	0.80	0.08	**2.23**	1.91-2.61	<0.01
	Spaniel	1.5 (1.3-1.8)	0.45	0.08	**1.58**	1.34-1.80	<0.01
	Toy	2.2 (1.8-2.6)	0.90	0.10	**2.45**	2.02-2.99	<0.01
	Unclassified	1.5 (1.2-1.8)	0.43	0.09	**1.53**	1.29-1.81	<0.01
	Unknown	0.9 (0.5-1.3)	0.18	0.22	**1.20**	0.77-1.85	0.43
	Working dog	1.4 (1.1-1.8)	0.45	0.11	**1.57**	1.27-1.93	<0.01
Practice type	Small animal (Intercept)	1.3 (1.1-1.5)	-4.85	0.07	**0.01**	0.01-0.01	
	Mixed	1.7 (1.0-2.3)	0.18	0.17	**1.20**	0.86-1.66	0.29
	Small & equine	1.2 (0.7-1.6)	-0.10	0.40	**0.91**	0.42-1.98	0.80
	Small & large	1.5 (1.0-1.9)	0.08	0.35	**1.09**	0.55-2.15	0.81
Accreditation	Not accredited (Intercept)	1.7 (1.1-2.4)	-4.65	0.18	**0.01**	0.01-0.01	
	1+ accredited site	1.4 (1.1-1.6)	-0.19	0.19	**0.83**	0.57-1.20	0.33
Hospital status	No hospital site (Intercept)	1.5 (1.3-1.8)	-4.78	0.07	**0.01**	0.01-0.01	
	1+ hospital site	1.0 (0.9-1.1)	-0.17	0.16	**0.84**	0.62-1.15	0.28
Referral interest	No (Intercept)	1.5 (1.2-1.7)	-4.80	0.08	**0.01**	0.01-0.01	
	Yes	1.2 (1.0-1.5)	-0.06	0.14	**0.94**	0.72-1.23	0.66
Employed RCVS AVP [e]	None (Intercept)	1.5 (1.2-1.7)	-4.79	0.07	**0.01**	0.01-0.01	
	1+ AVP	1.3 (1.0-1.5)	-0.13	0.16	**0.87**	0.64-1.19	0.39
Employed RCVS specialist [e]	None (Intercept)	1.4 (1.2-1.6)	-4.81	0.06	**0.01**	0.01-0.01	
	1+ specialist	0.8 (0.5-1.1)	-0.26	0.38	**0.77**	0.37-1.62	0.49
Continuous factors							
Age (years)	Intercept		-4.81	0.07	**0.01**	0.01-0.01	
	Age - linear		0.20	0.04	**1.22**	1.13-1.32	<0.01
	Age - quadratic		-0.03	0.03	**0.97**	0.93-1.02	0.23
	Age - cubic		0.04	0.02	**1.04**	1.01-1.08	0.01
rIMD [f]	Intercept		-4.82	0.06	**0.01**	0.01-0.01	
	rIMD		0.02	0.02	**1.02**	0.97-1.07	0.39
Dogs per household [g]	Intercept		-4.82	0.06	**0.01**	0.01-0.01	
	Dogs per household		0.02	0.03	**1.03**	0.97-1.09	0.40
Dogs per km^2 [g]	Intercept		-4.82	0.06	**0.01**	0.01-0.01	
	Dogs per km		-0.02	0.02	**0.98**	0.94-1.02	0.31

[a] 95% Confidence Interval
[b] Standard Error

[c] Odds Ratio
[d] Vonholdt et al., 2010
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived
[g] Aegerter et al., 2017

Table S6

Descriptive summary of the percentage of total sick canine consultations prescribed a topical antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [b]	OR [c]	CI	*P*
Categorical factors							
Country	England (Intercept)	14.1 (13.9-14.6)	-1.82	0.02	**0.16**	0.16-0.17	
	Scotland	13.4 (11.9-14.9)	0.03	0.05	**1.03**	0.93-1.13	0.58
	Wales	14.7 (13.9-15.6)	-0.06	0.06	**0.95**	0.85-1.06	0.34
Main presenting complaint	Gastroenteric (Intercept)	1.8 (1.2-2.5)	-3.99	0.05	**0.02**	0.02-0.02	
	Kidney disease	3.2 (2.4-4.1)	0.61	0.14	**1.84**	1.41-2.41	<0.01
	Other unwell	15.5 (15.0-16.0)	2.28	0.04	**9.79**	8.99-10.65	<0.01
	Pruritus	31.7 (30.7-32.8)	3.23	0.04	**25.30**	23.23-27.55	<0.01
	Respiratory	2.9 (2.3-3.6)	0.48	0.07	**1.61**	1.40-1.85	<0.01
	Trauma	6.6 (6.2-7.0)	1.32	0.05	**3.75**	3.43-4.11	<0.01
	Tumour	5.9 (5.5-6.4)	1.22	0.05	**3.38**	3.04-3.76	<0.01
Sex	Female (Intercept)	13.6 (13.3-14.0)	-1.87	0.02	**0.15**	0.15-0.16	
	Male	14.8 (14.4-15.2)	0.10	0.01	**1.11**	1.08-1.13	<0.01
Neuter status	Un-neutered (Intercept)	15.0 (14.6-15.4)	-1.76	0.02	**0.17**	0.17-0.18	
	Neutered	13.8 (13.4-14.2)	-0.10	0.01	**0.91**	0.88-0.93	<0.01
Microchip status	Un-microchipped (Intercept)	13.4 (13.1-13.8)	-1.89	0.02	**0.15**	0.15-0.16	
	Microchipped	14.9 (14.5-15.3)	0.13	0.01	**1.14**	1.11-1.16	<0.01
Vaccination status	Un-vaccinated (Intercept)	13.2 (12.9-13.6)	-1.90	0.02	**0.15**	0.14-0.16	
	Vaccinated	14.6 (14.3-15.0)	0.11	0.01	**1.12**	1.09-1.15	<0.01
Insurance status	Un-insured (Intercept)	14.5 (14.2-14.9)	-1.80	0.02	**0.17**	0.16-0.17	
	Insured	13.6 (13.2-14.1)	-0.07	0.01	**0.93**	0.91-0.96	<0.01
Owner urban status	Urban (Intercept)	14.4 (14.0-14.8)	-1.81	0.02	**0.16**	0.16-0.17	
	Rural	14.0 (13.6-14.4)	-0.04	0.02	**0.97**	0.94-1.00	0.02
Genetic breed group [d]	Retriever (Intercept)	15.3 (14.7-16.0)	-1.72	0.02	**0.18**	0.17-0.19	
	Crossbreed	13.3 (12.9-13.7)	-0.01	0.06	**0.99**	0.89-1.11	0.92
	Ancient / spitz	15.0 (13.5-16.5)	-0.16	0.02	**0.85**	0.82-0.89	<0.01
	Herding	8.2 (7.7-8.7)	-0.70	0.04	**0.50**	0.46-0.54	<0.01
	Mastiff-like	17.0 (16.4-17.6)	0.11	0.03	**1.11**	1.06-1.17	<0.01
	Scent hound	13.3 (12.2-14.3)	-0.18	0.04	**0.83**	0.77-0.91	<0.01
	Sight hound	5.3 (4.4-6.2)	-1.17	0.07	**0.31**	0.27-0.36	<0.01
	Small terrier	12.8 (12.3-13.3)	-0.22	0.02	**0.80**	0.76-0.84	<0.01
	Spaniel	16.1 (15.5-16.6)	0.04	0.02	**1.04**	0.99-1.08	0.13
	Toy	15.5 (14.7-16.3)	-0.02	0.03	**0.99**	0.92-1.05	0.64
	Unclassified	15.5 (14.9-16.1)	0.01	0.02	**1.01**	0.96-1.06	0.73
	Unknown	12.1 (10.8-13.4)	-0.29	0.06	**0.75**	0.66-0.85	<0.01
	Working dog	13.7 (12.9-14.5)	-0.13	0.03	**0.88**	0.82-0.93	<0.01
Practice type	Small animal (Intercept)	14.3 (13.9-14.8)	-1.81	0.02	**0.16**	0.16-0.17	
	Mixed	13.6 (12.9-14.3)	-0.08	0.04	**0.92**	0.85-1.00	0.05
	Small & equine	16.2 (14.3-18.2)	0.17	0.09	**1.19**	0.99-1.42	0.06
	Small & large	14.5 (13.6-15.4)	0.00	0.09	**1.00**	0.84-1.2	0.99
Accreditation	Not accredited (Intercept)	13.3 (12.3-14.4)	-1.90	0.05	**0.15**	0.14-0.16	
	1+ accredited site	14.4 (14.0-14.7)	0.09	0.05	**1.10**	1.00-1.20	0.05
Hospital status	No hospital site (Intercept)	14.0 (13.6-14.4)	-1.83	0.02	**0.16**	0.15-0.17	
	1+ hospital site	15.0 (14.3-15.7)	0.07	0.04	**1.07**	0.99-1.15	0.09
Referral interest	No (Intercept)	14.2 (13.9-14.6)	-1.83	0.02	**0.16**	0.16-0.17	
	Yes	14.2 (13.5-15.0)	0.03	0.03	**1.03**	0.96-1.1.0	0.47
Employed RCVS AVP [e]	None (Intercept)	13.9 (13.5-14.3)	-1.84	0.02	**0.16**	0.15-0.17	
	1+ AVP	15.3 (14.6-15.9)	0.08	0.04	**1.08**	1.01-1.16	0.03
Employed RCVS specialist [e]	None (Intercept)	14.3 (13.9-14.6)	-1.82	0.02	**0.16**	0.16-0.17	
	1+ specialist	12.0 (10.2-13.7)	-0.18	0.09	**0.84**	0.70-1.00+	0.05
Continuous factors							
Age (years)	Intercept		-1.74	0.02	**0.20**	0.17-0.18	
	Age - linear		-0.32	0.01	**0.73**	0.71-0.75	<0.01
	Age - quadratic		-0.12	0.01	**0.89**	0.88-0.90	<0.01
	Age - cubic		0.03	0.01	**1.03**	1.02-1.04	<0.01
rIMD [f]	Intercept		-1.82	0.02	**0.16**	0.16-0.17	<0.01
	rIMD		0.01	0.01	**1.01**	0.99-1.02	0.32
Dogs per household [g]	Intercept		-1.82	0.02	**0.16**	0.16-0.17	
	Dogs per household		-0.01	0.01	**0.99**	0.98-1.01	0.40
Dogs per km^2 [g]	Intercept		-1.82	0.02	**0.16**	0.16-0.17	
	Dogs per km		0.00	0.01	**1.00**	0.99-1.01	0.98

[a] 95% Confidence Interval
[b] Standard Error
[c] Odds Ratio

[d] Vonholdt et al., 2010
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived
[g] Aegerter et al., 2017

Table S7

Descriptive summary of the percentage of total sick feline consultations where an animal was prescribed at least one antimicrobial (systemic, topical or systemic highest priority critically important (HPCIA) compared against animal breed, including breeds where in excess of 1,000 consultations were recorded.

Genetic breed group	Cat breed	n consults	Systemic		Topical		Systemic HPCIA	
			% [b]	95% CI [c]	%	95% CI	%	95% CI
Asian	Burmese	1,314	**32.1**	28.8-35.4	**8.9**	6.8-11.0	**18.8**	15.6-22.0
Asian	Siamese	1,814	**35.3**	31.9-38.7	**5.0**	3.9-6.2	**17.6**	14.8-20.4
Crossbreed	Crossbreed	93,599	**32.9**	31.9-33.8	**5.7**	5.5-5.9	**17.2**	16.1-18.4
Unclassified	Bengal	1,024	**37.0**	33.1-40.9	**8.8**	6.7-11.0	**20.3**	16.8-23.8
Unknown	Unknown	4,244	**34.0**	32.4-35.6	**7.4**	6.5-8.3	**18.0**	15.6-20.3
West Europe	British	2,707	**29.1**	26.1-32.2	**9.5**	7.3-11.6	**14.6**	12.2-17.0
West Europe	Persian	1,870	**29.9**	26.6-33.2	**11.0**	9.3-12.7	**16.1**	13.4-18.8

[a] Lipinski et al., 2008
[b] Percentage of consultations where at least one antimicrobial was prescribed
[c] 95% Confidence Interval
[d] Highest priority critically important antimicrobial

Table S8

Descriptive summary of the percentage of total sick feline consultations prescribed a systemic antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [b]	OR [c]	CI	*P*
Categorical factors							
Country	England (Intercept)	32.5 (31.5-33.5)	-0.77	0.03	**0.46**	0.44-0.49	
	Scotland	37.0 (33.9-40.1)	0.06	0.09	**1.06**	0.90-1.26	0.47
	Wales	33.4 (29.9-37.0)	0.34	0.10	**1.40**	1.15-1.71	<0.01
Main presenting complaint	Gastroenteric (Intercept)	30.5 (28.1-32.9)	-0.83	0.04	**0.44**	0.41-0.47	
	Kidney disease	20.7 (18.8-22.6)	-0.47	0.05	**0.62**	0.56-0.69	<0.01
	Other unwell	27.2 (26.1-28.2)	-0.20	0.03	**0.82**	0.78-0.87	<0.01
	Pruritus	26.8 (24.9-28.7)	-0.23	0.03	**0.79**	0.74-0.85	<0.01
	Respiratory	53.0 (50.6-55.4)	0.91	0.04	**2.49**	2.32-2.69	<0.01
	Trauma	53.5 (52.3-54.7)	0.99	0.03	**2.68**	2.53-2.84	<0.01
	Tumour	20.7 (19.0-22.3)	-0.58	0.05	**0.56**	0.51-0.62	<0.01
Sex	Female (Intercept)	30.1 (29.1-31.1)	-0.88	0.03	**0.42**	0.39-0.44	
	Male	35.4 (34.4-36.4)	0.26	0.02	**1.30**	1.26-1.34	<0.01
Neuter	Un-neutered (Intercept)	33.1 (31.9-34.2)	-0.74	0.03	**0.48**	0.45-0.51	
	Neutered	32.8 (31.8-33.8)	-0.00	0.02	**1.00**	0.96-1.04	0.87
Microchip status	Un-microchipped (Intercept)	32.2 (31.3-33.2)	-0.80	0.03	**0.45**	0.43-0.48	
	Microchipped	33.9 (32.8-35.1)	0.14	0.02	**1.15**	1.12-1.19	<0.01
Vaccination status	Un-vaccinated (Intercept)	33.6 (32.6-34.6)	-0.73	0.03	**0.48**	0.46-0.51	
	Vaccinated	32.2 (31.2-33.2)	-0.03	0.02	**0.97**	0.94-1.00	0.05
Insurance status	Un-insured (Intercept)	33.8 (32.8-34.8)	-0.71	0.03	**0.49**	0.47-0.52	
	Insured	28.9 (27.7-30.1)	-0.20	0.02	**0.82**	0.79-0.86	<0.01
Owner urban status	Urban (Intercept)	32.1 (31.1-33.1)	-0.76	0.03	**0.47**	0.44-0.50	
	Rural	34.8 (33.3-36.2)	0.04	0.02	**1.05**	1.00-1.09	0.04
Genetic breed group [d]	West Europe (Intercept)	30.8 (29.1-32.4)	-0.88	0.04	**0.41**	0.38-0.45	
	Asian	33.1 (30.7-35.5)	0.14	0.05	**1.15**	1.04-1.27	0.01
	Crossbreed	32.9 (31.9-33.8)	0.14	0.03	**1.16**	1.0-1.23	<0.01
	Mediterranean	42.5 (27.5-57.4)	0.48	0.26	**1.61**	0.97-2.67	0.06
	Unclassified	34.7 (32.2-37.3)	0.22	0.06	**1.25**	1.11-1.39	<0.01
	Unknown	34.0 (32.4-35.6)	0.18	0.05	**1.19**	1.08-1.31	<0.01
Practice type	Small animal (Intercept)	32.2 (31.1-33.2)	-0.79	0.03	**0.45**	0.43-0.48	
	Mixed	35.4 (32.8-38.0)	0.24	0.08	**1.27**	1.10-1.47	<0.01
	Small & equine	28.7 (22.4-35.0)	-0.02	0.17	**0.98**	0.70-1.38	0.90
	Small & large	37.7 (32.7-42.7)	0.25	0.16	**1.29**	0.94-1.76	0.11
Accreditation	Not accredited (Intercept)	36.4 (34.2-38.6)	-0.54	0.08	**0.58**	0.50-0.68	
	1+ accredited site	32.2 (31.2-33.2)	-0.23	0.09	**0.80**	0.67-0.94	<0.01
Hospital status	No hospital site (Intercept)	33.3 (32.2-34.4)	-0.72	0.03	**0.49**	0.46-0.52	
	1+ hospital site	31.2 (29.5-32.9)	-0.13	0.07	**0.88**	0.76-1.01	0.07
Referral interest	No (Intercept)	33.2 (32.1-34.3)	-0.71	0.03	**0.49**	0.46-0.53	
	Yes	31.9 (30.1-33.8)	-0.11	0.06	**0.90**	0.79-1.01	0.08
Employed RCVS AVP [e]	None (Intercept)	33.4 (32.3-34.5)	-0.71	0.03	**0.49**	0.46-0.53	
	1+ AVP	31.3 (29.4-33.2)	-0.18	0.07	**0.84**	0.73-0.96	0.01
Employed RCVS specialist [e]	None (Intercept)	32.9 (32.0-33.9)	-0.74	0.03	**0.48**	0.45-0.51	
	1+ specialist	29.0 (24.7-33.4)	-0.14	0.17	**0.87**	0.62-1.21	0.41
Continuous factors							
Age (years)	Intercept		-0.64	0.03	**0.53**	0.50-0.56	
	Age - linear		-0.53	0.02	**0.59**	0.57-0.61	<0.01
	Age - quadratic		-0.13	0.01	**0.87**	0.86-0.89	<0.01
	Age - cubic		0.12	0.01	**1.13**	1.11-1.15	<0.01
rIMD [f]	Intercept		-0.74	0.03	**0.48**	0.45-0.50	
	IMD		-0.03	0.01	**0.97**	0.96-0.99	<0.01
Cats per household [g]	Intercept		-0.74	0.03	**0.48**	0.45-0.50	
	Cats per household		-0.00	0.01	**1.00**	0.97-1.02	0.73
Cats per km^2 [g]	Intercept		-0.74	0.03	**0.48**	0.45-0.50	
	Cats per km		-0.02	0.01	**0.98**	0.97-1.00	0.02

[a] 95% Confidence Interval
[b] Standard Error
[c] Odds Ratio
[d] Lipinski et al., 2008
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived
[g] Aegerter et al., 2017

Table S9

Descriptive summary of the percentage of total sick feline consultations prescribed a systemic highest priority critically important antimicrobial (HPCIA). Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [b]	OR [c]	CI	*P*
Categorical factors							
Country	England (Intercept)	17.1 (16.0-18.1)	-1.71	0.06	**0.18**	0.16-0.20	
	Scotland	17.5 (9.8-25.3)	0.07	0.12	**1.07**	0.86-1.35	0.54
	Wales	18.0 (14.9-21.1)	0.18	0.17	**1.20**	0.86-1.68	0.29
Main presenting complaint	Gastroenteric (Intercept)	6.9 (5.9-7.9)	-2.71	0.07	**0.07**	0.06-0.08	
	Kidney disease	13.7 (11.9-15.5)	0.75	0.07	**2.12**	1.84-2.44	<0.01
	Other unwell	14.2 (13.2-15.2)	0.79	0.05	**2.20**	2.02-2.41	<0.01
	Pruritus	19.8 (18.1-21.5)	1.17	0.05	**3.23**	2.92-3.57	<0.01
	Respiratory	29.4 (26.9-31.9)	1.72	0.05	**5.57**	5.00-6.19	<0.01
	Trauma	27.1 (24.6-29.5)	1.68	0.05	**5.35**	4.88-5.87	<0.01
	Tumour	12.3 (11.0-13.7)	0.57	0.07	**1.77**	1.55-2.01	<0.01
Sex	Female (Intercept)	16.3 (15.2-17.4)	-1.76	0.06	**0.17**	0.15-0.19	
	Male	17.9 (16.7-19.1)	0.13	0.02	**1.14**	1.10-1.18	<0.01
Neuter	Un-neutered (Intercept)	16.3 (15.0-17.7)	-1.78	0.06	**0.17**	0.15-0.19	
	Neutered	17.3 (16.2-18.4)	0.10	0.03	**1.11**	1.06-1.16	<0.01
Microchip status	Un-microchipped (Intercept)	16.8 (15.7-17.9)	-1.73	0.06	**0.18**	0.16-0.20	
	Microchipped	17.6 (16.4-18.8)	0.08	0.02	**1.09**	1.05-1.13	<0.01
Vaccination status	Un-vaccinated (Intercept)	17.5 (16.3-18.7)	-1.67	0.06	**0.19**	0.17-0.21	
	Vaccinated	16.8 (15.7-17.8)	-0.05	0.02	**0.95**	0.91-0.98	<0.01
Insurance status	Un-insured (Intercept)	17.6 (16.5-18.8)	-1.67	0.06	**0.19**	0.17-0.21	
	Insured	15.0 (13.7-16.2)	-0.13	0.03	**0.88**	0.84-0.93	<0.01
Owner urban status	Urban (Intercept)	16.5 (15.4-17.6)	-1.71	0.06	**0.18**	0.16-0.20	
	Rural	18.7 (16.9-20.5)	0.06	0.03	**1.06**	1.01-1.11	0.03
Genetic breed group [d]	West Europe (Intercept)	15.3 (13.8-16.9)	-1.88	0.07	**0.15**	0.13-0.17	
	Asian	17.2 (15.2-19.3)	0.19	0.07	**1.21**	1.06-1.37	<0.01
	Crossbreed	17.2 (16.1-18.3)	0.20	0.04	**1.23**	1.13-1.33	<0.01
	Mediterranean	22.0 (7.1-36.9)	0.11	0.32	**1.12**	0.60-2.09	0.73
	Unclassified	16.6 (14.7-18.6)	0.15	0.07	**1.16**	1.01-1.34	0.04
	Unknown	18.0 (15.6-20.3)	0.14	0.06	**1.15**	1.02-1.30	0.02
Practice type	Small animal (Intercept)	16.5 (15.3-17.8)	-1.73	0.06	**0.18**	0.16-0.20	
	Mixed	18.8 (16.1-21.5)	0.10	0.16	**1.11**	0.81-1.50	0.52
	Small & equine	18.2 (12.7-23.7)	0.27	0.37	**1.30**	0.64-2.67	0.47
	Small & large	20.1 (14.4-25.9)	0.28	0.32	**1.32**	0.71-2.46	0.38
Accreditation	Not accredited (Intercept)	14.5 (10.5-18.4)	-1.93	0.16	**0.15**	0.11-0.20	
	1+ accredited site	17.7 (16.6-18.7)	0.27	0.17	**1.31**	0.93-1.83	0.12
Hospital status	No hospital site (Intercept)	17.0 (15.7-18.4)	-1.67	0.06	**0.19**	0.17-0.21	
	1+ hospital site	17.4 (15.6-19.1)	-0.14	0.15	**0.87**	0.65-1.16	0.34
Referral interest	No (Intercept)	17.5 (16.1-18.8)	-1.67	0.07	**0.19**	0.17-0.22	
	Yes	16.2 (14.3-18.2)	-0.08	0.12	**0.92**	0.72-1.17	0.50
Employed RCVS AVP [e]	None (Intercept)	17.3 (15.9-18.6)	-1.69	0.06	**0.19**	0.16-0.21	
	1+ AVP	16.8 (14.8-18.7)	-0.04	0.14	**0.96**	0.73-1.27	0.77
Employed RCVS specialist [e]	None (Intercept)	17.1 (16.0-18.2)	-1.70	0.06	**0.18**	0.16-0.21	
	1+ specialist	16.5 (12.5-20.5)	0.06	0.34	**1.07**	0.55-2.06	0.85
Continuous factors							
Age (years)	Intercept		-1.51	0.06	**0.22**	0.20-0.25	
	Age - linear		-0.38	0.02	**0.68**	0.66-0.71	<0.01
	Age - quadratic		-0.20	0.01	**0.82**	0.80-0.83	<0.01
	Age - cubic		0.17	0.01	**1.18**	1.16-1.20	<0.01
rIMD [f]	Intercept		-1.69	0.06	**0.18**	0.17-0.21	
	IMD		0.00	0.01	**1.00**	0.98-1.03	0.83
Cats per household [g]	Intercept		-1.69	0.06	**0.18**	0.17-0.21	
	Cats per household		0.01	0.02	**1.01**	0.98-1.04	0.54
Cats per km^2 [g]	Intercept		-1.69	0.06	**0.18**	0.16-0.21	
	Cats per km		-0.01	0.01	**0.99**	1.00-1.01	0.28

[a] 95% Confidence Interval
[b] Standard Error
[c] Odds Ratio
[d] Lipinski et al., 2008
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived
[g] Aegerter et al., 2017

Table S10

Descriptive summary of the percentage of total sick feline consultations prescribed a topical antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI [a])	β	SE [a]	OR [b]	CI [c]	*P*
Categorical factors							
Country	England (Intercept)	6.0 (5.8-6.3)	-2.77	0.02	**0.06**	0.06-0.07	
	Scotland	6.6 (5.5-7.7)	0.07	0.09	**1.07**	0.90-1.28	0.45
	Wales	6.6 (6.0-7.2)	0.14	0.09	**1.15**	0.97-1.36	0.11
Main presenting complaint	Gastroenteric (Intercept)	1.1 (0.6-1.6)	-4.47	0.10	**0.01**	0.01-0.01	
	Kidney disease	0.8 (0.5-1.1)	-0.34	0.23	**0.72**	0.46-1.11	0.14
	Other unwell	7.1 (6.8-7.4)	1.89	0.10	**6.59**	5.40-8.04	<0.01
	Pruritus	10.8 (10.0-11.7)	2.35	0.11	**10.49**	8.54-12.89	<0.01
	Respiratory	5.7 (4.9-6.4)	1.63	0.12	**5.10**	4.07-6.40	<0.01
	Trauma	4.6 (4.3-5.0)	1.43	0.11	**4.20**	3.41-5.17	<0.01
	Tumour	1.7 (1.3-2.1)	0.42	0.16	**1.53**	1.13-2.08	0.01
Sex	Female (Intercept)	6.0 (5.7-6.2)	-2.78	0.03	**0.06**	0.06-0.07	
	Male	6.2 (6.0-6.5)	0.04	0.03	**1.05**	0.99-1.10	0.11
Neuter status	Un-neutered (Intercept)	7.3 (6.8-7.7)	-2.57	0.04	**0.08**	0.07-0.08	
	Neutered	5.9 (5.6-6.1)	-0.23	0.03	**0.79**	0.74-0.85	<0.01
Microchip status	Un-microchipped (Intercept)	5.9 (5.7-6.2)	-2.79	0.03	**0.06**	0.06-0.07	
	Microchipped	6.4 (6.0-6.7)	0.09	0.03	**1.09**	1.03-1.16	<0.01
Vaccination status	Un-vaccinated (Intercept)	6.2 (5.9-6.5)	-2.74	0.03	**0.06**	0.06-0.07	
	Vaccinated	6.0 (5.8-6.3)	-0.02	0.03	**0.98**	0.93-1.03	0.42
Insurance status	Un-insured (Intercept)	6.3 (6.1-6.5)	-2.72	0.02	**0.07**	0.06-0.07	
	Insured	5.3 (4.9-5.8)	-0.19	0.04	**0.83**	0.77-0.89	<0.01
Owner urban status	Urban (Intercept)	6.0 (5.8-6.3)	-2.77	0.03	**0.06**	0.06-0.07	
	Rural	6.3 (5.9-6.7)	0.04	0.03	**1.04**	0.97-1.11	0.26
Genetic breed group [d]	West Europe (Intercept)	9.5 (8.4-10.6)	-2.28	0.05	**0.10**	0.09-0.11	
	Asian	6.9 (5.8-8.0)	-0.29	0.09	**0.75**	0.63-0.88	<0.01
	Crossbreed	5.7 (5.5-5.9)	-0.54	0.05	**0.58**	0.53-0.64	<0.01
	Mediterranean	5.5 (0.5-10.4)	-0.47	0.49	**0.62**	0.24-1.64	0.34
	Unclassified	8.3 (7.2-9.5)	-0.13	0.09	**0.88**	0.74-1.05	0.17
	Unknown	7.4 (6.4-8.3)	-0.29	0.08	**0.75**	0.64-0.88	<0.01
Practice type	Small animal (Intercept)	6.0 (5.8-6.3)	-2.77	0.03	**0.06**	0.06-0.07	
	Mixed	6.4 (5.9-7.0)	0.07	0.06	**1.08**	0.96-1.21	0.20
	Small & equine	5.7 (4.5-6.8)	-0.11	0.14	**0.89**	0.68-1.18	0.43
	Small & large	6.4 (5.5-7.3)	0.09	0.12	**1.09**	0.86-1.39	0.47
Accreditation	Not accredited (Intercept)	5.9 (5.2-6.5)	-2.77	0.06	**0.06**	0.06-0.07	
	1+ accredited site	6.2 (5.9-6.4)	0.02	0.07	**1.02**	0.90-1.16	0.74
Hospital status	No hospital site (Intercept)	6.0 (5.7-6.2)	-2.76	0.03	**0.06**	0.06-0.07	
	1+ hospital site	6.5 (6.1-6.9)	0.04	0.06	**1.05**	0.94-1.16	0.42
Referral interest	No (Intercept)	6.0 (5.8-6.3)	-2.78	0.03	**0.06**	0.06-0.07	
	Yes	6.3 (5.9-6.8)	0.08	0.05	**1.08**	0.98-1.19	0.10
Employed RCVS AVP [e]	None (Intercept)	6.1 (5.9-6.4)	-2.75	0.03	**0.06**	0.06-0.07	
	1+ AVP	6.0 (5.6-6.4)	-0.03	0.05	**0.97**	0.87-1.08	0.57
Employed RCVS specialist [e]	None (Intercept)	6.1 (5.9-6.3)	-2.75	0.02	**0.06**	0.06-0.07	
	1+ specialist	5.3 (4.1-6.6)	-0.13	0.14	**0.88**	0.66-1.16	0.36
Continuous factors							
Age (years)	Intercept		-2.86	0.03	**0.06**	0.05-0.06	
	Age - linear		-0.29	0.03	**0.75**	0.70-0.79	<0.01
	Age - quadratic		0.04	0.02	**1.04**	1.01-1.08	0.01
	Age - cubic		-0.04	0.02	**0.96**	0.93-0.99	0.01
rIMD [f]	Intercept		-2.76	0.02	**0.06**	0.06-0.07	
	IMD		-0.04	0.02	**0.96**	0.93-0.99	0.01
Cats per household [g]	Intercept		-2.75	0.02	**0.06**	0.06-0.07	
	Cats per household		0.01	0.02	**1.01**	0.97-1.04	0.72
Cats per km^2 [g]	Intercept		-2.75	0.02	**0.06**	0.06-0.07	
	Cats per km		0.01	0.01	**1.01**	0.98-1.03	0.72

[a] 95% Confidence Interval
[b] Standard Error
[c] Odds Ratio
[d] Lipinski et al., 2008
[e] Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status
[f] Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

[g] Aegerter et al., 2017